INSTRUCTION MANUAL
1503L-P

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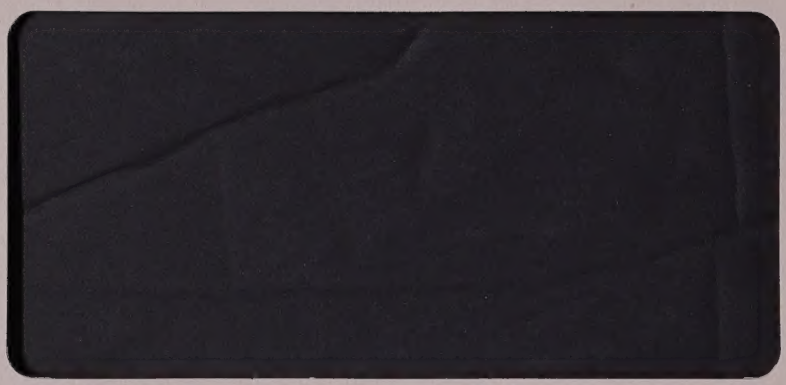

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INSTRUCTION MANUAL
1503L-P

Invertron®

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the California Instruments Model 1503L-3P AC Power System.

1.2 SPECIFICATIONS

Table 1-1 contains the operating specifications of the 1503L-3P AC Power System. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, using external sense, 25 ±1°C, after 15 minute warm-up and under constant line and load conditions.

TABLE 1-1
OUTPUT SPECIFICATIONS

Total power: 1667 VA at 100% of voltage range at 35°C.
1500 VA at 100% of voltage range at 50°C.

Power/phase: 556 VA at 100% of voltage range at 35°C.
500 VA at 100% of voltage range at 50°C.

Power factor: 0 to 1.0.

Current/phase:

135V RANGE		270V RANGE	
35°C	50°C	35°C	50°C
4.12	3.70	2.06	1.85

For other voltage ranges: Current per Phase = VA (per phase)/voltage range

Peak repetitive current per phase: 250% of the current rating at 50°C

Peak nonrepetitive current per phase:
270% of the current rating at 50°C (10 milliseconds).

Voltage range: 135 and 270 (Standard)
67.5 and 135 (LV Option)
156 and 312 (HV Option)
200 and 400 (EHV Option)

Total Distortion (to 300 kHz, at full-scale voltage driving full linear load):
1% from 45 Hz to 2 kHz,
2% from 2 kHz to 5 kHz.

OUTPUT SPECIFICATIONS (continued)

Line regulation: 0.02% for ±10% line change.

Load regulation: 0.05% no load to full load.

Voltage accuracy (true rms, 25°C, no load):
±0.135 vrms from 5 to 135 vrms
±0.540 vrms from 135 to 270 vrms
±1.5 vrms from 5 to 200 vrms (EHV option), 45 to 1 KHz
±3.0 vrms from 200 to 400 vrms (EHV option), 45 to 1 KHz

Add 2% of programmed value below 45 Hz.

Frequency range: 45 Hz to 5 KHz (at a 50°C maximum current only)
45 Hz to 1 KHz (EHV option)
45 Hz to 2 KHz at 35°C maximum current

Frequency Resolution: 0.01 Hz to 99.99
0.1 Hz to 999.9
1 Hz to 5000 Hz

Frequency accuracy (at 25 degrees C):
±0.001% of programmed value.

Phase angle accuracy: (each phase similarly loaded)
±2 degrees from 45 Hz to 2 KHz,
±3 degrees from 2 KHz to 5 KHz.
±15 degrees, Phase A to Ext Sync.

PROTECTION

Output overload: Unit set to default, output relays open. Must be reprogrammed after fault is cleared.

Output short circuit: Unit set to default, output relays open. Must be reprogrammed after short is cleared.

Sense line fault: Unit set to default, output relays open.

Temperature: Unit set to default, output relays open. Must be reprogrammed after cooling.

MEASUREMENTS (at 25°C ambient)

Voltage accuracy: ±1 Vrms.

Voltage resolution: 0.1 Vrms for 1 digit

Current accuracy: ±0.1 Arms.

Current resolution: 0.01 Arms.

True power accuracy: ±10 W.

True power resolution: 1 W.

Apparent power resolution: 1 W.

Power factor resolution: 0.001.

Frequency accuracy: ±0.02 Hz from 45 to 99.99 Hz,
±0.2 Hz from 100 to 499.9 Hz,
±0.5 Hz from 500 to 999.9 Hz,
±10 Hz from 1 to 5 KHz.

Frequency resolution: 0.01 Hz from 45 to 99.99 Hz,
0.1 Hz from 100 to 999.9 Hz,
1 Hz from 1 KHz to 5 KHz.

Phase angle accuracy: ±2 degrees from 45 Hz to 2 KHz,
±3 degrees from 2 to 5 KHz.

Phase angle resolution: 0.1 degree.

NOTE: For frequencies below 45 Hz add 2% of measured value to voltage, current and power measurement accuracy.

SUPPLEMENTAL SPECIFICATIONS

LINE INPUT

Voltage: 103 - 127 vac,
206 - 254 vac.

Current: 27 arms max.

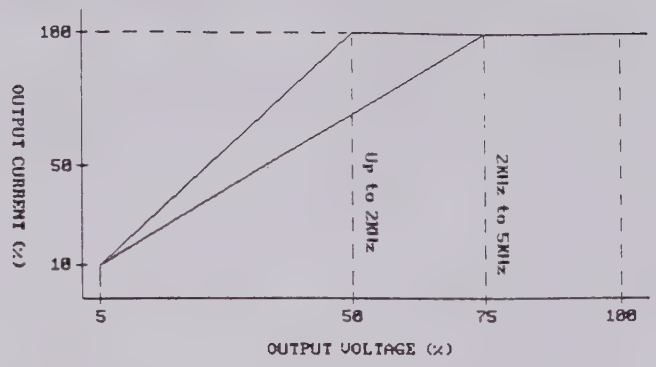
Frequency: 47 - 440 Hz.

Efficiency: 75% typical.

Surge current (turn-on): 185 amps max.

SUPPLEMENTAL OUTPUT SPECIFICATIONS

Full current range:



Output noise (20 kHz to 1 MHz): 60 millivolts rms (typical)

Voltage temperature coefficient: ±0.02v/degree C.

Voltage stability (24 hours, constant line, load and temp.):

±0.015% of full scale.

Voltage Settling Time: (from start of voltage change from 5.0 VRMS or higher voltage to a higher voltage to within 2% of final value)

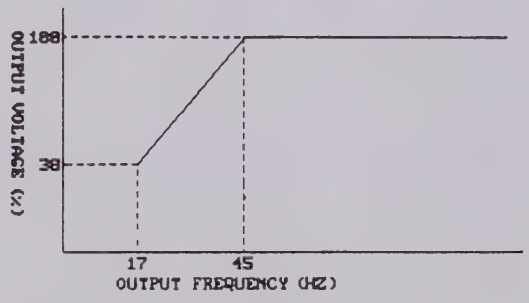
No-load: 16 milliseconds

Full-load: 0.3 seconds (16 milliseconds to within 15% of final value)

Steady-State Output Impedance (ohms)

= (Voltage Range) x (0.0005)/Full-load current

Frequency Range
At less than Full Scale Voltage: (Refer to graph below)



Frequency Temperature Coefficient: ±5 ppm of value per °C

SUPPLEMENTAL SPECIFICATIONS (continued)

Frequency Stability: ±15 ppm of value per year

Isolation (line input to output): greater than 500 vrms.

CONTROL

Front panel controls: Circuit breaker,
20 key keypad,
Voltmeter phase selector switch.

Bus: IEEE 488.

Subsets: SH1, AH1, T6, L3, SR1, RL2, DC1, DT1.

Codes and formats:

Numeric representation: NR1, NR2, or NR3.

Headers: HR1 or HR2 (upper or lower case).

Message separators: SR1.

Data transfer rate: 200 kbytes per second.

Language: California Instruments specific (CIIL with MATE option).

Functions

* Voltage: range - 0 to 100% of programmed voltage range,
resolution - 0.1 Vrms,
initial - 5.0 Vrms.

Voltage range: range - 0 to 135,
0 to 270.
resolution - 0.1 vrms.
initial - 135.0.

Frequency: range - 45 to 5000 Hz.
resolution - 0.01 Hz from 45 to 99.99 Hz,
0.1 Hz from 100 to 999.9 Hz,
1 Hz from 1000 to 5000 Hz.
initial - 60 Hz.

* Phase angle: range - 0 to ±999.9 degrees.
resolution - 0.1 degree.
initial - B, 240.0 degrees,
C, 120.0 degrees.

NOTE (*) Independent control for each phase

SUPPLEMENTAL SPECIFICATIONS (continued)

CONTROL

Functions

* Current limit: range - 0 to 3.70 amps.
  resolution - 0.01 amp
  initial - 3.70 amps.

Ramp/Sweep: May ramp/sweep voltage, frequency, phase, and current limit; up to two functions simultaneously.

External sync: range - 45 Hz to 5 kHz internal/external.
initial - internal.

Self test: RAM/ROM check.

Storage registers: 0 through 15 with link capabilities.

* Waveform: sine wave or square wave (optional).
  initial - sine wave.

Output relay: Bus programmable only. Normally open.

Confidence test: (only with MATE CIIL option) RAM/ROM, output voltage, phase angle, current limit and frequency tests.

Phase A drop point: range - 0 to 999.9 degrees.
resolution - 0.1 degree.
initial - n/a.

Service request: Option to enable after fault, errors, and measurements.

Group execute trigger: Bus trigger for any setup parameter, also to halt program execution.

Status reporting: Remote - status byte and message.
Local - message only.

Calibration: Output phase angle, output amplitude, and all measurements.

Remote sense: Allows ±10% correction for load wiring losses. Must be connected.

NOTE (*) Independent control for each phase.

SUPPLEMENTAL SPECIFICATIONS (continued)

Function strobe: NPN transistor of optical isolator is switched off to indicate change of programmed voltage, phase or frequency.

Remote shutdown: Sets output voltages to zero and opens output relays when this TTL line is pulled low.

External sync: Allows synchronization to 5 volt, 45 to 5000 Hz pulse. Output will track frequency and phase of sync signal.

Panel meter: 300 volt analog meter with three position output phase selector switch. Accuracy: 5% of full scale.

Display: 32 digit liquid crystal display.

Indicators:
- POWER ON,
- OVERTEMP,
- OVERLOAD,
- HIGH RANGE,
- REMOTE.

Dimensions: Width - 19" (48.3 cm).
Height - 5.25" (13.3 cm).
Depth - 23.1" (58.7 cm).

Weight: 85 lbs (38.6 kg).

Material: aluminum - front panel, top cover.
steel - rear panel, chassis.

Finish: front panel - painted gray 26440 per Fed Std 595.
steel - zinc plate type 2, class 2.
aluminum - iridite.

Air intake/exhaust: intake from sides, exhaust to rear.

Modularity: modular construction of all major assemblies.

Connectors:

Input - Kulka 9-85-3.

Output - Kulka 3695A-8.

Sense - Amp 1-480705-0
with Amp 350689-1 socket contacts.

Sense mate - Amp 1-480704-0
with Amp 350690-1 pin contacts.

Interface - 3M 3367-1000 socket.

Interface mate - 3M 3366-1001 plug.

SUPPLEMENTAL SPECIFICATIONS (continued)

Chassis slides: Zero Manufacturing CTN-1-20-E94.

Operating temperature: 0 to 50 degrees C.

Storage temperature: -40 to 85 degrees C.

Operating altitude: 0 to 6000 feet (0 to 1830 meters).

OPTIONS

LK: Allows unit to be operated as a master (LKM option) or slave (LKS option) in synchronization with other California Instruments controllers. The LK option cannot be used if the AX option is installed.

MATE: Includes internal confidence loads, DFI output, and CIIL as program language.

LV: Low voltage output; 0 to 67.5 Vrms/0 to 135 Vrms.

HV: High voltage output; 0 to 156 Vrms/0 to 312 Vrms.

EHV: Extra High Voltage output; 0 to 200Vrms/0 to 400Vrms.

2P: Two phase output; Phase B is disabled and Phase C is set to 90 degrees with respect to Phase A.

AX: Auxiliary outputs; provides low power fourth and fifth phases, D and E. The AX option cannot be used if the LK option is installed.

(All specifications at 25°C and verified with TRMS voltmeter. The Phase D sense lines must be connected to the Phase D output.)

Phase D

Voltage: 26.0 Vrms ±2%, fixed.

Current: 3.0 Arms, max.

Frequency: 360 to 440 Hz (tracks main outputs).

Phase: Tracks Phase A.

Phase accuracy: ±2 degrees, all outputs at half load.

Distortion: 1%, maximum with linear load.

Line regulation: ±0.05% using external sense.

Load regulation: ±0.05% using external sense.

Phase E

Voltage: 5.0 Vrms ±5%, fixed.

Current: 5.0 Arms, max.

Frequency: 360 to 440 Hz (tracks main output).

Phase: Tracks Phase A.

Distortion: 1% maximum with linear load.

Line regulation: ±0.1%.

Load regulation: ±10%.

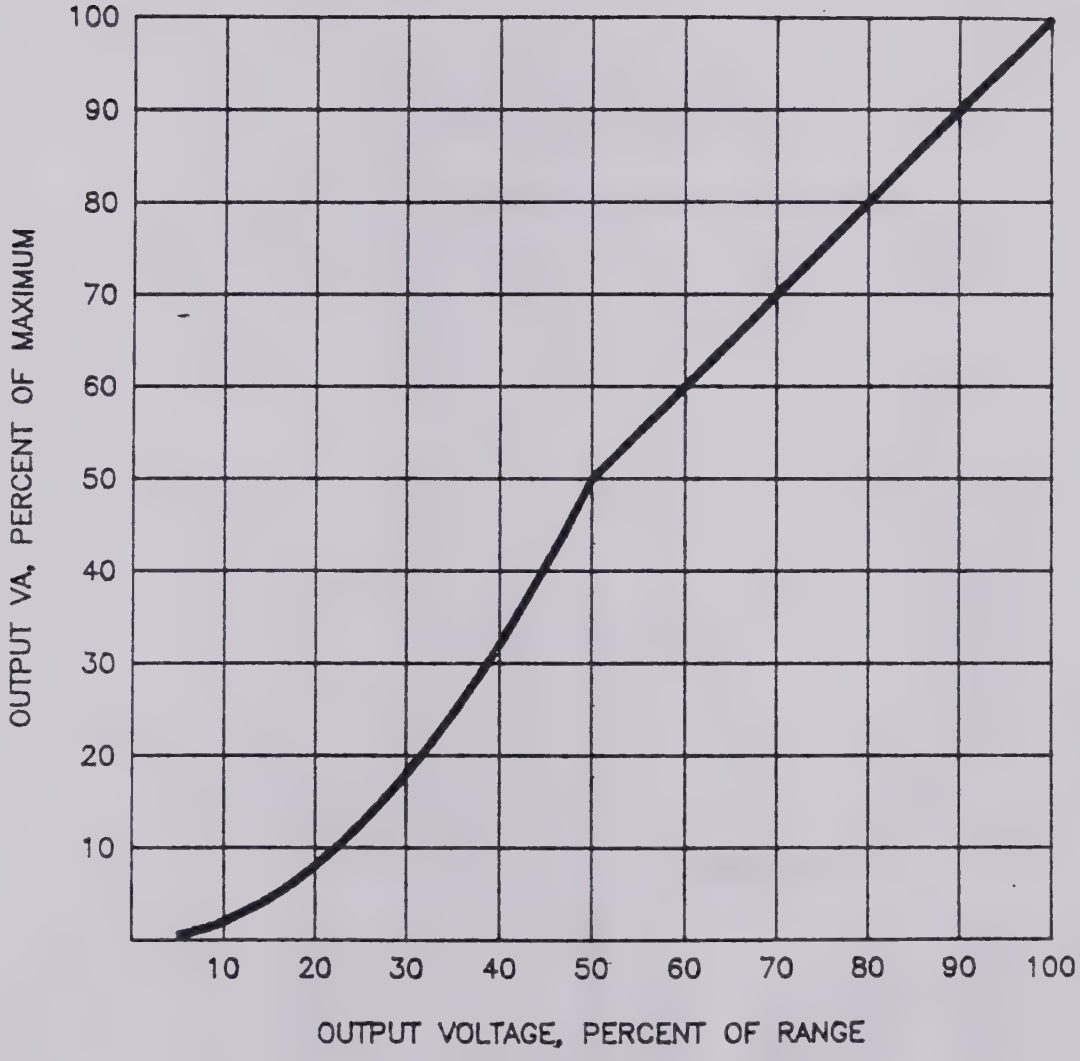
SQW (SQUARE WAVE): (performance into a resistive load)
Frequency - 50 Hz to 5 kHz.
Rise/fall time - 40 microseconds.
Overshoot - 20%.
Droop - 10%.

704D: Option that performs all tests described by MIL-STD-704D.

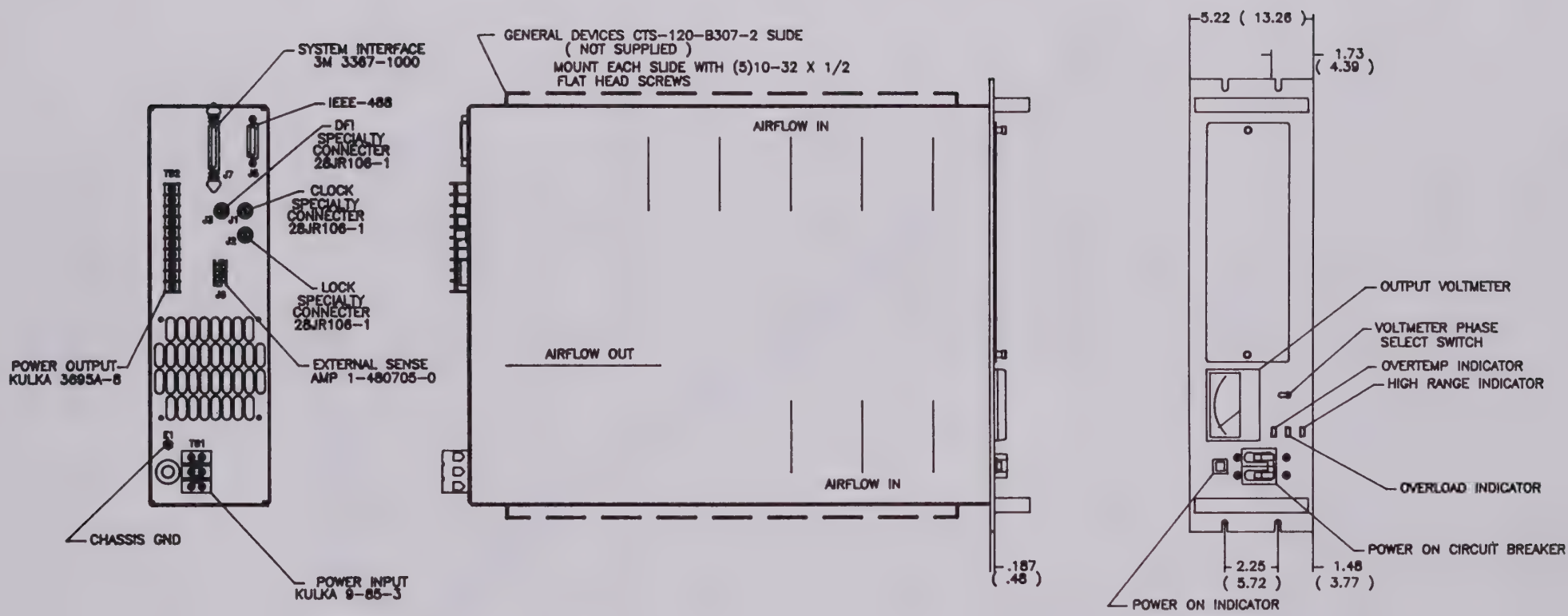
160C: Option that performs all tests described by RTCA/DO-160C.

1.3 GENERAL DESCRIPTION

The California Instruments Model 1503L-3P is a high efficiency, low distortion power source that provides up to 1667 VA three phase power. The 1503L-3P is illustrated in Figure 1-1. Full power output is available in two voltage ranges and over the frequency range from 45 Hz to 2000 Hz. 1500VA three-phase power is available from 45 Hz to 5000 Hz. The EHV option is limited to 1000 Hz.



OUTPUT POWER CURVE



OUTLINE DRAWING

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval.

Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.2 POWER REQUIREMENTS

2.2.1 AC LINE VOLTAGE

The 1503L power source has been designed to operate from either of the following AC line voltage ranges:

1) 103 to 127 volts
2) 206 to 254 volts.

CAUTION

The 1503L will be damaged if it is operated at an input voltage that is outside its configured input range.

The input voltage range is set at the factory. Section 2.3 gives the procedure to change the input voltage range.

2.2.2 LINE FREQUENCY OPERATING RANGE

The 1503L power source has been designed to operate over the line frequency range from 47 Hz to 440 Hz.

2.2.3 INPUT POWER

The input power to the 1503L power source depends upon line and load conditions and may be as high as 2300 watts.

2.3 INPUT VOLTAGE RANGE SELECTION

WARNING

Voltages up to 360 VDC and 270 VAC are present in certain sections of this power source. This equipment generates potentially lethal voltages.

on contact may result if personnel fail to observe safety precautions. Do not touch electric circuits when power is applied. Servicing should only be performed by trained personnel.

The input voltage range is configured by two wires and eight jumpers. See Figure 2-1 for the location of these components.

2.3.1 LOW INPUT VOLTAGE RANGE CONFIGURATION

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The low input voltage range is set by making the following connections inside the power source:

Wire 4008-050-005	From CB1B-LN to A4-E2.
Wire 4008-050-011	From DS1 to A4-E7.
Jumper A4-J1	From 2 to 5.
Jumper A4-J1	From 3 to 4.
Jumper A4-J2	From 2 to 5.
Jumper A4-J2	From 3 to 4.
Jumper A4-J3	From 2 to 5.
Jumper A4-J3	From 3 to 4.
Jumper A4-J4	From 2 to 5.
Jumper A4-J4	From 3 to 4.

2.3.2 HIGH INPUT VOLTAGE RANGE CONFIGURATION

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The high input voltage range is set by making the following connections inside the power source:

Wire 4008-050-005	From CB1B-LN to CR1-AC.
Wire 4008-050-011	From DS1 to A4-E4.
Jumper A4-J1	From 1 to 6.
Jumper A4-J1	From 2 to 3.
Jumper A4-J2	From 1 to 6.
Jumper A4-J2	From 2 to 3.
Jumper A4-J3	From 1 to 6.
Jumper A4-J3	From 2 to 3.
Jumper A4-J4	From 1 to 6.
Jumper A4-J4	From 2 to 3.

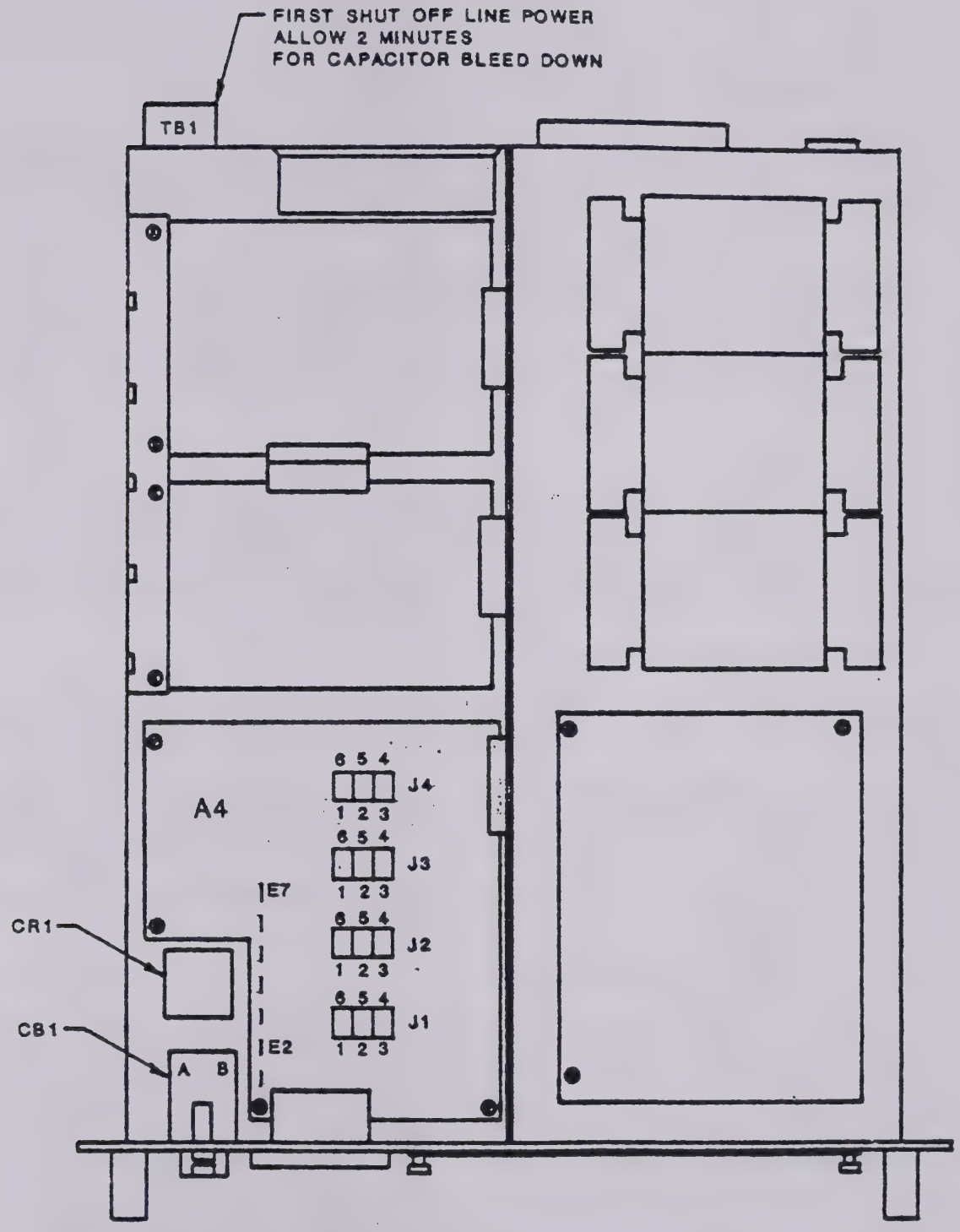


FIGURE 2-1

1503L INPUT VOLTAGE RANGE SELECTION

2.4 MECHANICAL INSTALLATION

The 1503L power source has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the bottom with a shelf-track or supported from the sides with optional rack slides.

The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 2-2.

2.5 INPUT WIRING

The 1503L power source must be operated from a three-wire single phase service. The required mains voltage is divided in two ranges. See Section 1.2 for the input voltage ranges. The mains source should have a current rating greater than or equal to the power source circuit breaker rating, 30 amps.

2.6 OUTPUT CONNECTION

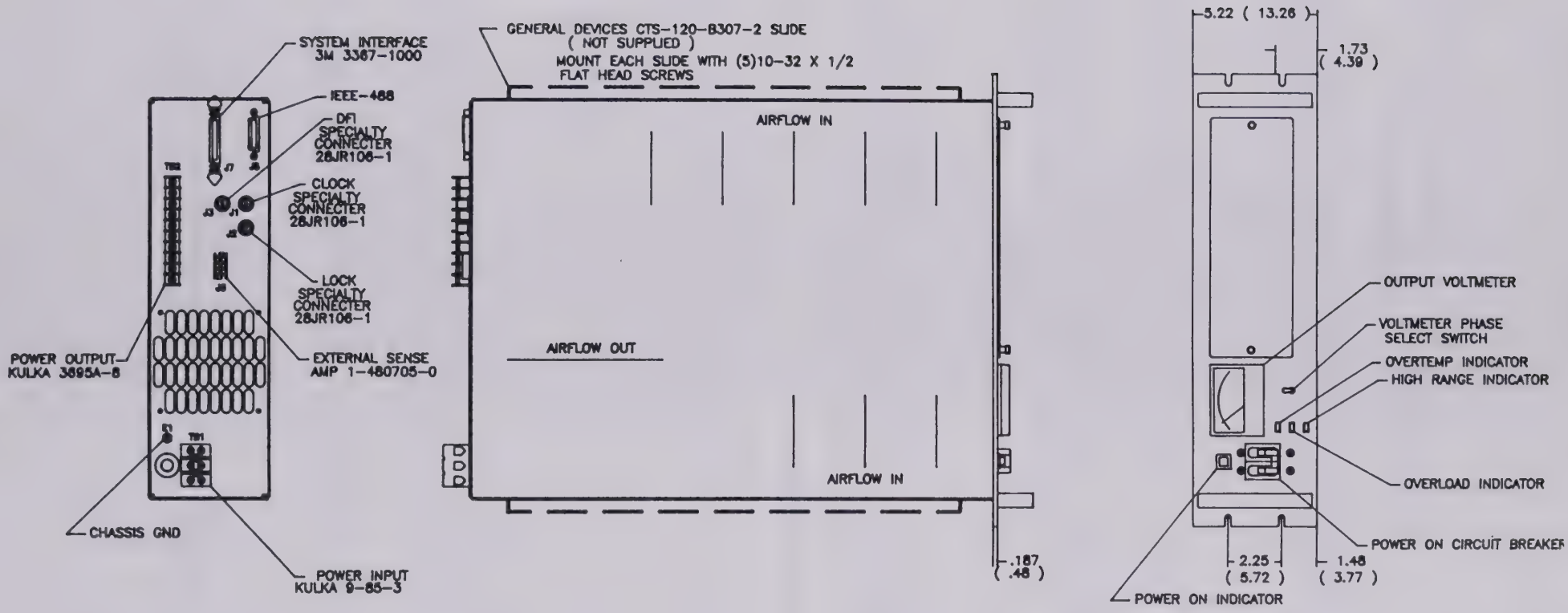
The output terminal block, TB2, is located at the rear of the 1503L power source. All load connections must be made at TB2.

The remote sense inputs allow the power source output voltages to be monitored directly at the load and must be connected. The remote sense wires are connected at J6 on the 1503L rear panel.

See Figure 2-2 for the location of the output terminal block and remote sense input.

2.6.1 OUTPUT POWER WIRING

The output power cables must be large enough to avoid excessive voltage drops due to the impedance of the wires. The voltage drop across the cables should be limited to 2 percent of the 1503L power source output voltage. Table 2-1 lists the minimum acceptable wire size for a 1 percent line drop assuming a symmetrical load located 10 feet from the power source. The line drop listed in the table is due only to the resistance of the wire. At higher power source output frequencies, reactive losses may increase the line voltage drop. To reduce high frequency effects, bundle wires tightly together.



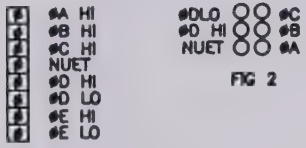


FIG 1

FIG 2

FIGURE 2-2

CALIFORNIA INSTRUMENTS 1503L

TABLE 2-1
MINIMUM WIRE SIZE
FOR 1 PERCENT LINE DROP

OUTPUT VOLTAGE	MAXIMUM LINE DROP	MAXIMUM PER PHASE CURRENT	LOOP LENGTH	MINIMUM REQUIRED WIRE GAUGE
Volts	Volts	Amps	Feet	AWG
135	1.35	4.12	20	22
270	2.70	2.06	20	28

The wire sizes specified in Table 2-1 are for single wire bundles and reflect the MINIMUM wire size required. If wires are in large bundles or are in confined spaces, the wire sizes should be doubled (wire gauge reduced by 3 wire gauge numbers).

NOTE

The wire gauge should be reduced by 3 wire gauge numbers for every time that the distance is doubled between the power source and the load. For example, use AWG 19 when operating on the 135 volt range with a load 20 feet from the power source.

2.6.2 REMOTE SENSE WIRING

The remote sense lines of the 1503L must be connected at all times for proper operation. Failure to connect the sense wires will cause the power controller to disable all outputs and indicate a fault.

The remote sense lines are connected to the 1503L power source using the connectors listed in Section 1.2 of this manual. The remote sense wires should be AWG 22 or larger. See Figure 2-2.

2.7 OUTPUT VOLTAGE RANGES

The 1503L is configured to operate on one of two possible voltage ranges, a high range and a low range. Activation of the high range is indicated on the front panel when the "HIGH RANGE" lamp is illuminated. No lamp is lit to indicate the low range.

Switching ranges is accomplished by programming the desired range through the keypad or the GPIB input.

CAUTION

Before a range change is made, verify that the output voltage and load are compatible and within the VA ratings of the 1503L, or damage to the load may occur.

2.8 FRONT PANEL CONTROLS

2.8.1 CIRCUIT BREAKER

The circuit breaker is used to switch power to the unit. When the circuit breaker is switched ON, the amber indicator lamp above the circuit breaker illuminates. See Figure 2-3.

2.8.2 VOLTMETER SELECTOR SWITCH

A voltmeter selector switch is located just below the front panel voltmeter. The three position switch changes the signal applied to the voltmeter among the three 1503L output phases. When the switch is to the top, Phase A is selected, in the middle, Phase B is selected, and down, Phase C is selected. See Figure 2-3.

2.8.3 KEYPAD

A 20-key keypad allows the power source to be manually programmed at the front panel.

2.8.4 VIEWING ANGLE

The knob labeled VIEW ANGLE may be turned to adjust the contrast of the front panel display.

2.9 FUNCTION TEST

2.9.1 INITIAL SETUP

Refer to Figure 2-4 for the recommended test setup. Ensure that the AC mains are of the proper voltage and frequency. Use #10 wire to connect the AC power line to the AC input terminal block, TB-1.

2.9.2 POWER ON

1) Apply AC line power to the 1503L power source.

2) Apply input power to the 1503L power source by setting the front panel circuit breaker to the "ON" position. At this time, no loads should be connected to the output terminal block, TB-2.

3) Verify that the POWER lamp is lit.

2.9.3 RANGE SWITCHING

1) Set the voltage range to high range. The HIGH RANGE lamp should be lit.

2) Set the power controller to 400 Hz. Adjust for 270 volts. Verify that the front panel voltmeter indicates 270 volts for all three phases.

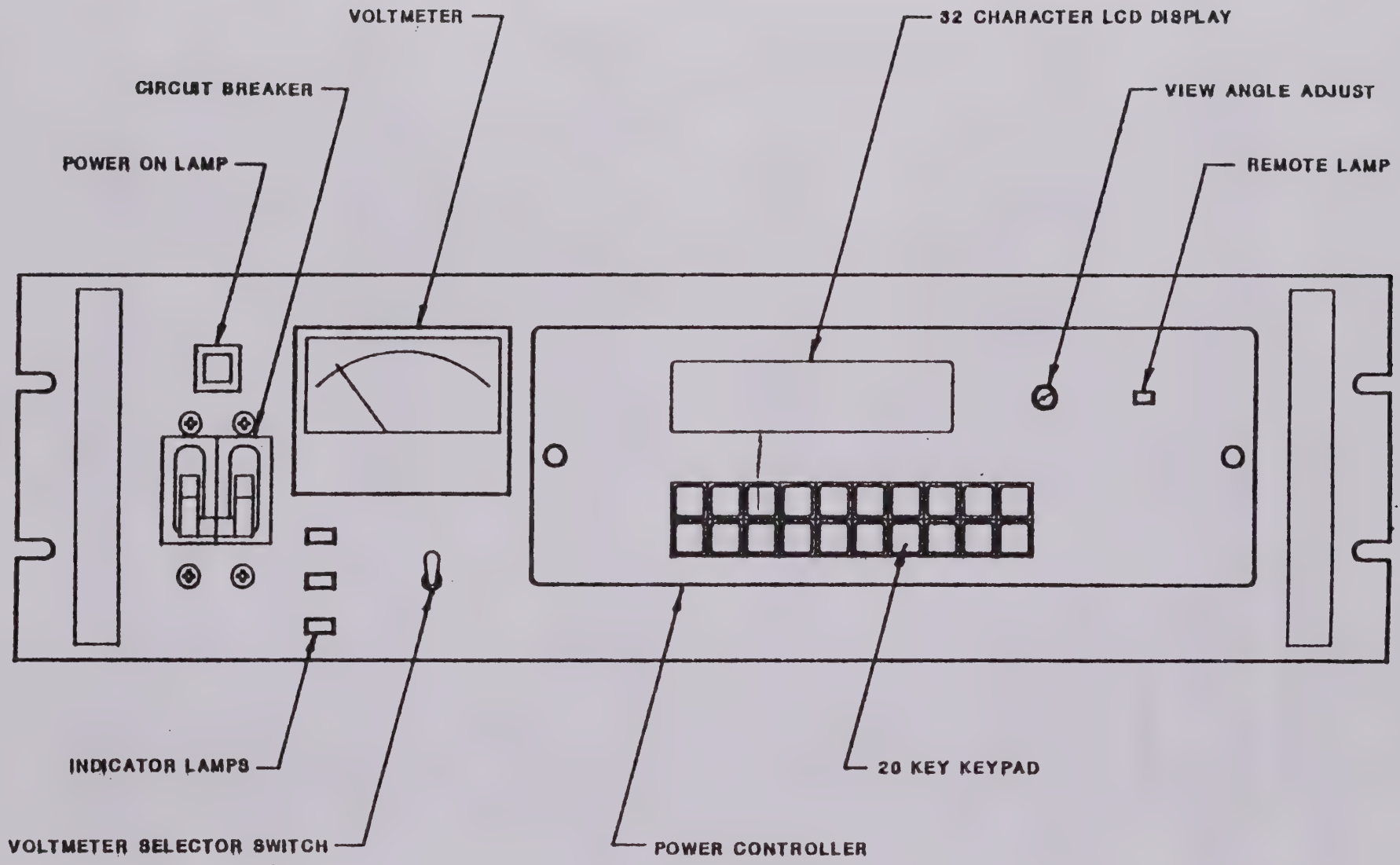


FIGURE 2-3

1503L FRONT PANEL

3) Change the voltage range to low range. The HIGH RANGE lamp should extinguish.

4) Adjust the power controller for 135 volts. Verify that the front panel voltmeter indicates 135 volts for all three phases.

2.9.4 NO LOAD/FULL LOAD/OVERLOAD TEST

NOTE: The following test calls for a 556 VA load on the 135 volt range. To calculate the load for another voltage range use the formula

$$\text{LOAD (Ohms)} = (\text{Voltage Range})^2 / 556$$

1) Observe each of the three outputs with the oscilloscope or distortion analyzer. The outputs should be clean sine waves having less than 1.0% distortion.

2) Apply full loads to each phase (32.7 ohms, 556 watts each). Verify that the voltage of each phase remains within 0.05% of the no-load voltage. The waveforms shall still appear clean on the oscilloscope and should contain less than 1% distortion. The OVERLOAD lamp should not be lit.

3) Remove the loads. Apply a short circuit for several seconds to the Phase A output. The outputs will be disabled and the voltages will be set to the default value.

4) Reprogram the outputs to 135 volts and repeat step 3 for the Phase B output and then for the Phase C output.

2.9.5 ADDITIONAL TESTS

1) Sections 2.9.3 and 2.9.4 may be repeated for any phase at any rated voltage and frequency within the specified load limits of the 1503L.

2) The Calibration Procedure in Section 4 of this manual should be used if more detailed evaluation of the 1503L is required.

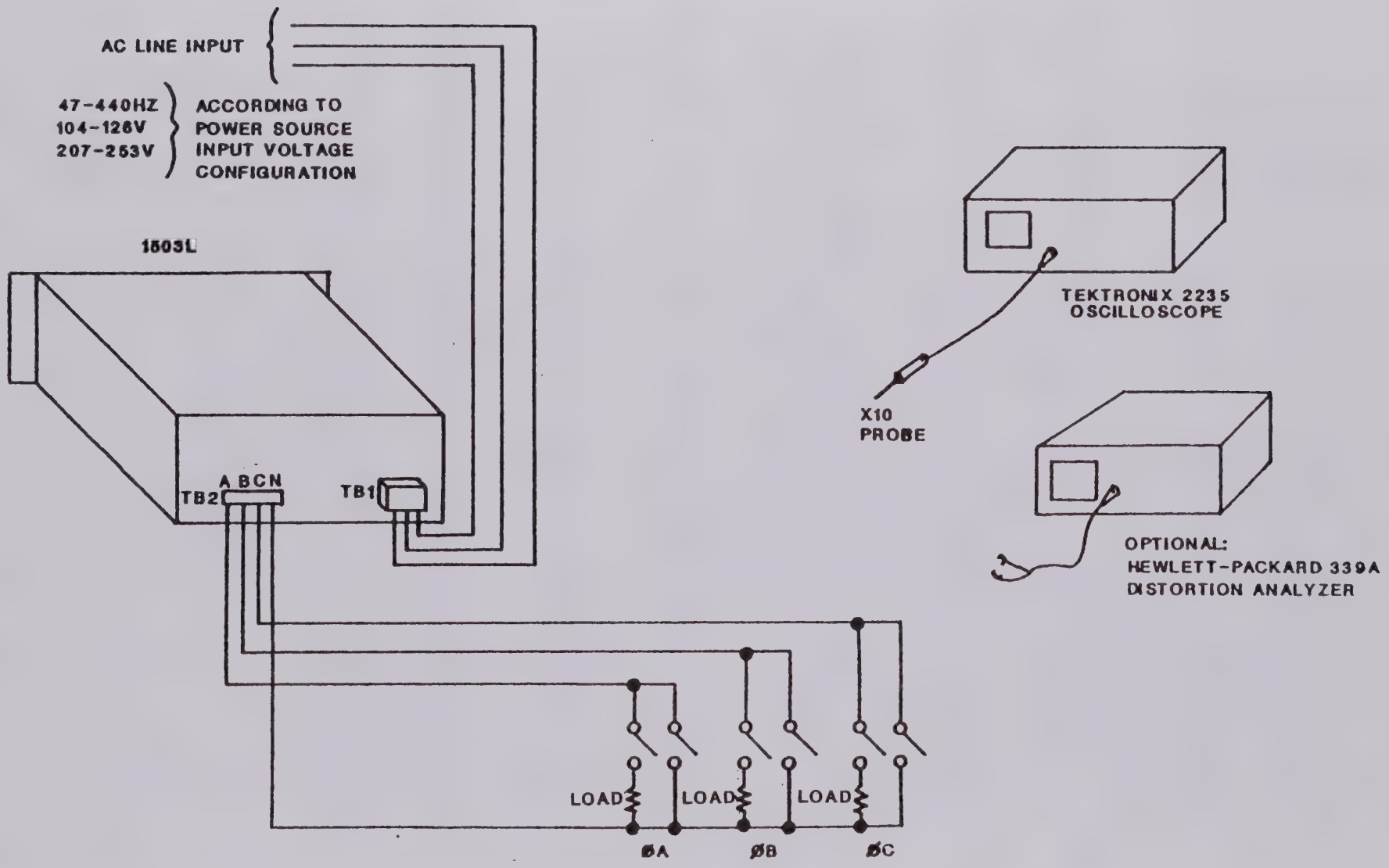


FIGURE 2-4

1503L FUNCTION TEST SETUP

SECTION 3

OPERATION

3.1 GENERAL

The California Instruments 1503L is a three-phase high efficiency AC power source. The power source consists of three separate, identical amplifiers, see Figure 3-1. The amplifiers share a common ground referenced input and a common but floating output neutral.

3.1.1 INPUT DRIVE

The amplifier drive signals to the 1503L are generated by an internal controller. The input drive is set by programming an output voltage via the keypad or GPIB.

3.1.2 OUTPUT VOLTAGE RANGES

The output voltage of the 1503L may be adjusted to any value within the range of the unit, and each phase may be adjusted independently of the other two phases.

Rated output VA and conversion efficiency is greatest when the output voltage is set near maximum. For this reason, the 1503L is designed to operate on one of two ranges, 135 volts full scale, or 270 volts full scale. The user should choose the range that allows operation nearest 100% of maximum voltage of the selected range. All three phases operate on the same range and switch simultaneously.

3.1.3 OUTPUT VA CAPABILITY

The output drive capability of each amplifier is limited by VA, volt-amps, rather than power, watts. An amplifier can drive a capacitive or inductive load to its full VA rating without delivering any power to the load.

The amount of VA available to a load may be determined from Figure 3-2, the output power curve. The output power curve rates available VA versus output voltage; it is a straight line between 50% and 100% of output voltage range (constant current) and a curve between 5% and 50% of output voltage range (linearly derated current versus voltage). Full VA is available only at full scale voltage. Full current is available at voltages between 50% and 100% of output voltage range.

The amplifier load may draw full VA at any power factor between 0 and +1 and may draw maximum current with a crest factor up to 2.5. (Crest factor is the ratio of peak current to rms current.) If the load draws current in excess of the maximum rated average or in excess of the rated crest factor, the amplifier will clip the voltage waveform to prevent excessive internal power dissipation.

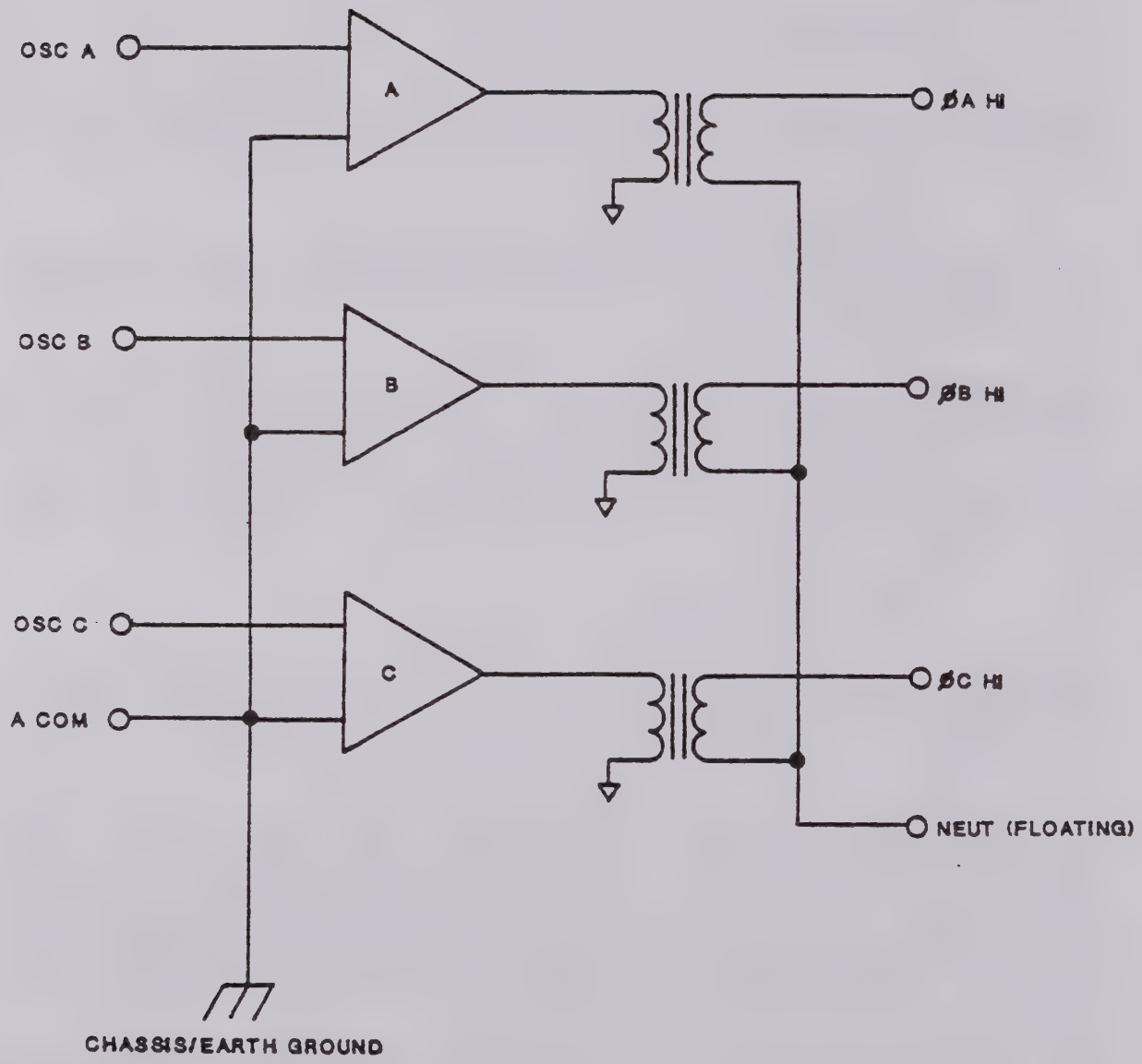


FIGURE 3-1

1503L THREE PHASE AMPLIFIER

3.2 FRONT PANEL CONTROLS, INDICATORS

Refer to Figure 3-3 for an illustration of the 1503L front panel.

CIRCUIT BREAKER:
The circuit breaker switches power to the 1503L. In the event that a fault within the power source causes an excessive draw of current, the circuit breaker will trip.

POWER ON LAMP:
The POWER lamp illuminates when the circuit breaker is switched on and the 1503L begins to draw input power.

VOLTMETER:
This average responding AC voltmeter is switched directly to the power source outputs. Full scale deflection is 300 volts. The voltmeter will indicate no voltage if the output relays are open.

METER SELECT SWITCH:
This three position switch selects which of the three phases will be displayed by the voltmeter. The upper position selects Phase A, the middle position selects Phase B, the lower position selects Phase C.

INDICATOR LAMPS:

OVERTEMP: This lamp illuminates when the temperature of the power amplifier heatsinks has surpassed a maximum set level. The power source controller will quickly detect a fault and disable the outputs. The outputs must be reprogrammed after the overtemperature condition has been eliminated.

OVERLOAD: This lamp illuminates when the power source has limited the outputs during a programmable current limit fault. Clipping of the output waveform will occur and the power source controller will eventually detect the fault and set the outputs to their default state.

HIGH RANGE: This lamp illuminates when the power source has switched to its high voltage range setting.

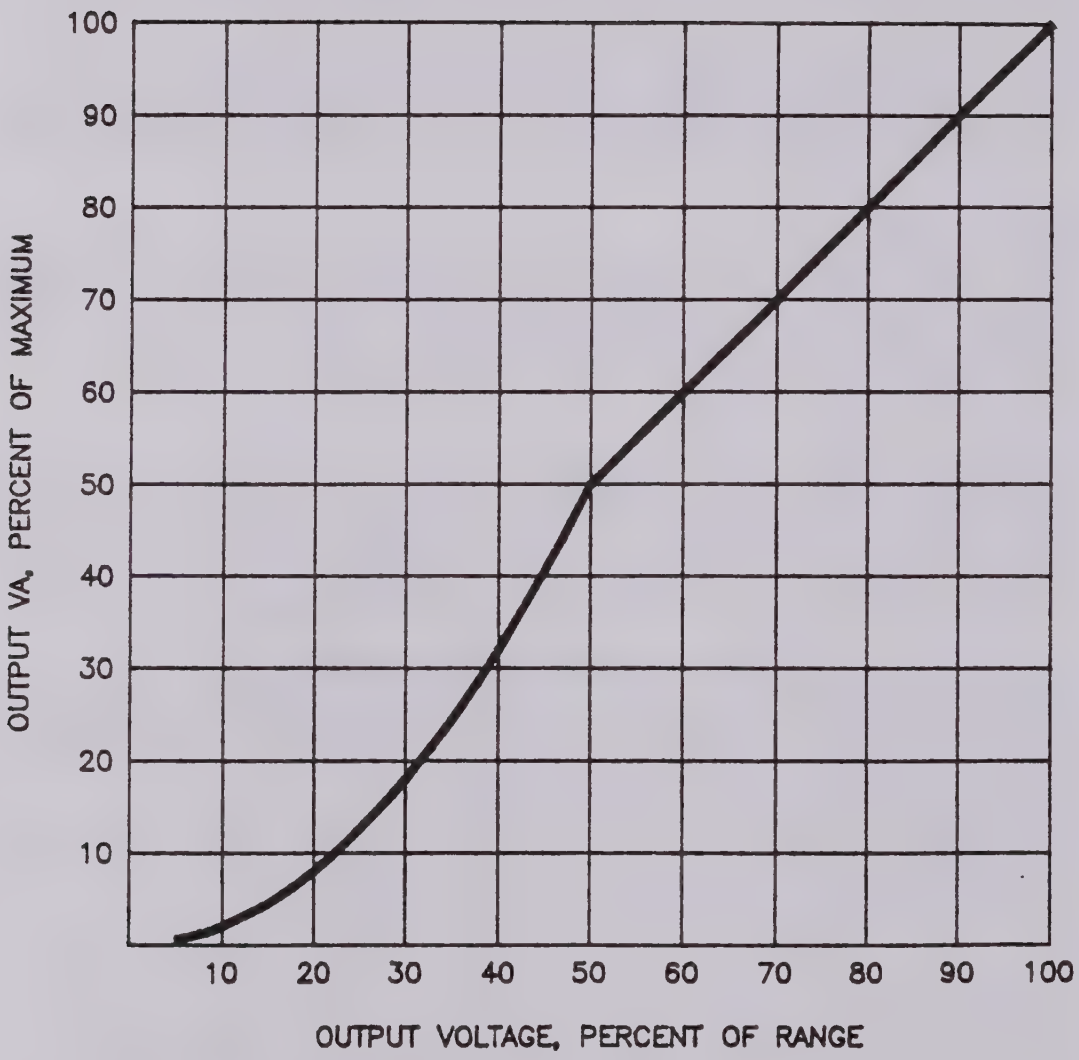


FIGURE 3-2 OUTPUT POWER CURVE

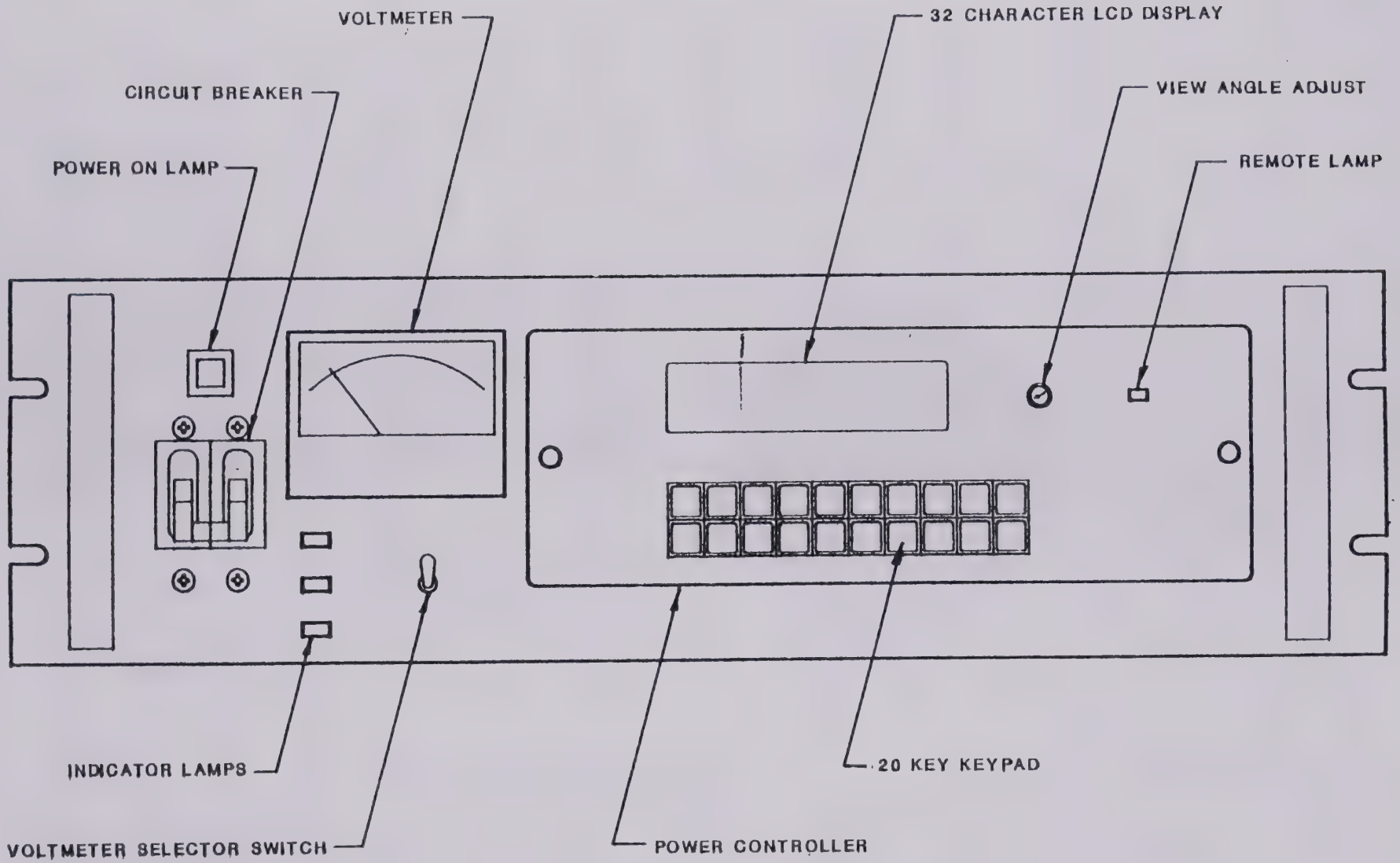


FIGURE 3-3

1503L FRONT PANEL

POWER CONTROLLER PANEL:

PROGRAMMABLE POWER CONTROLLER:
32-CHARACTER LCD DISPLAY

20-KEY KEYPAD

VIEW ANGLE: This knob adjusts the LCD display contrast for best viewing angle.

REMOTE: The REMOTE lamp is illuminated when the power source is programmed via the IEEE 488 bus. The front panel keypad is disabled when the REMOTE lamp is on.

3.3 REAR PANEL INTERFACE

Refer to Figure 3-4 for an illustration of the 1503L rear panel.

3.3.1 TB1 POWER INPUT

TB1-HI: This is the HI input power voltage terminal. Connect only to voltages corresponding to the input configuration. The service rating must be 30 amps or greater.

TB1-LO: This is the return for the TB1-HI line.

TB1-GND: This is the chassis ground connection and must be connected to earth ground.

3.3.2 TB2 POWER OUTPUT

TB2-1: This is the Phase A output terminal. Use TB2-4 for the return.

TB2-2: This is the Phase B output terminal. Use TB2-4 for the return.

TB2-3: This is the Phase C output terminal. Use TB2-4 for the return.

TB2-4: This is the floating neutral line for Phases A, B, and C.

TB2-5: This is the Phase D output terminal for the AX option. Use TB2-6 for the return.

TB2-6: This is the floating Phase D neutral for the AX option. This neutral is common with the Phase E neutral.

TB2-7: This is the Phase E output terminal for the AX option. Use TB2-6 for the return.

TB2-8: This is the floating Phase E neutral for the AX option. This neutral is common with the Phase D neutral.

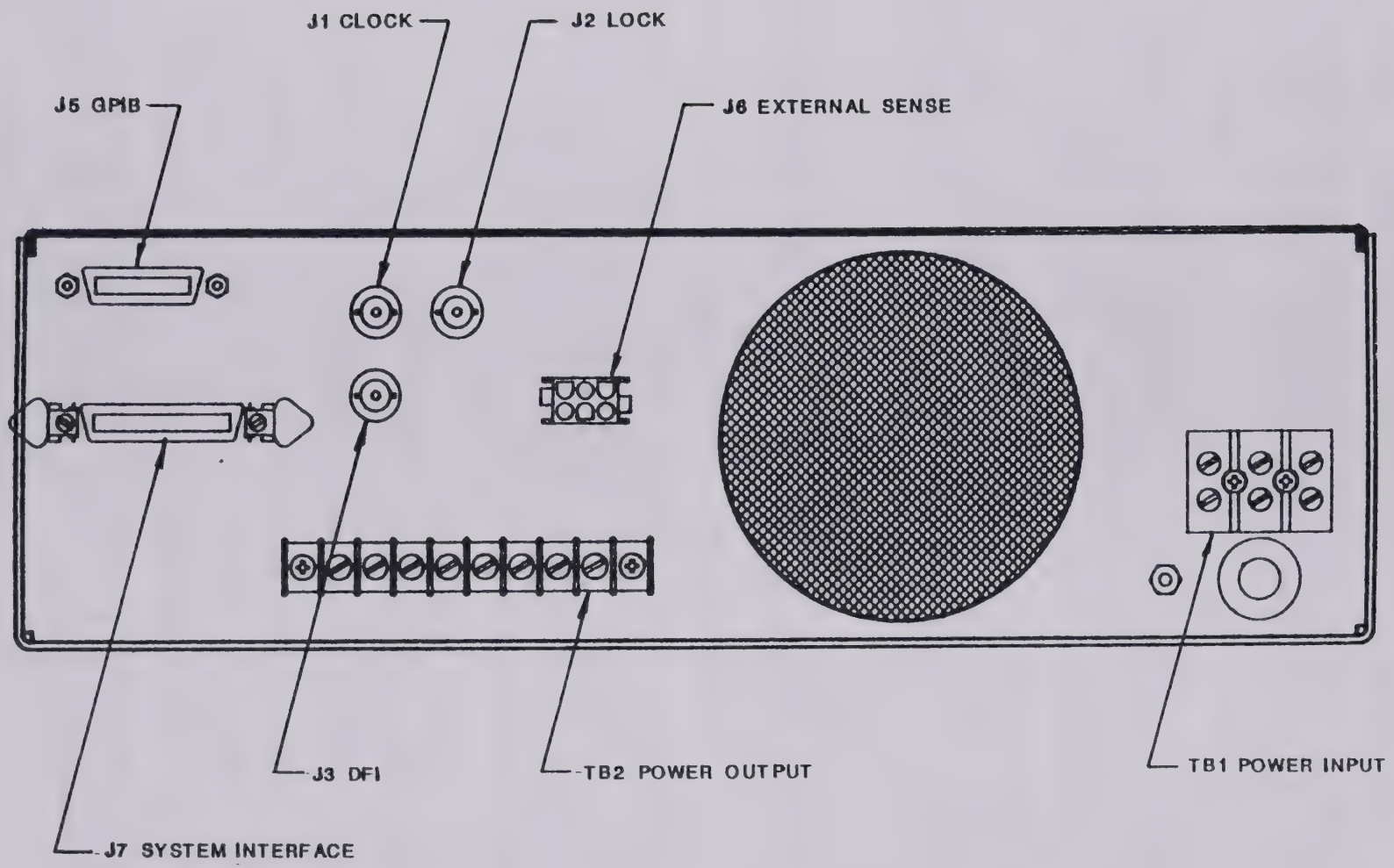


FIGURE 3-4
1503L REAR PANEL

3.3.3 J1 CLOCK

This signal is used by California Instruments power controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option.

3.3.4 J2 LOCK

This signal is used by California Instruments power controllers to synchronize oscillators in multiple power source systems. The connector is installed as an option.

3.3.5 J3 DFI

Discrete Fault Interrupt. This BNC connector is wired to a relay in the power controller. The normally closed relay contacts are held open by the power controller under normal running conditions. The contacts are allowed to close after a fault or if power is lost to the 1503L. The connector is installed as an option.

3.3.6 J5 GPIB

This is the IEEE-488 GPIB connector for use in power sources configured with programmable power controllers.

3.3.7 J6 EXTERNAL SENSE

The external sense lines allow the output voltages to be sensed at the load to account for impedance losses in output wiring. The Phase A, B, C, and NEUT lines must be connected to the output if an internal power controller is used. The Phase D HI and Phase D LO lines must be connected if the AX option is installed.

J6-1: Phase A High sense.

J6-2: Phase B High sense.

J6-3: Phase C High sense.

J6-4: Phase A, B, C Neutral sense.

J6-5: Phase D High sense.

J6-6: Phase D Low sense.

3.3.8 J7 SYSTEM INTERFACE

The system interface connector must be used to provide oscillator and control signals for power sources configured without an internal power controller.

J7-1, A COM: Analog common reference/return.

J7-2, Not used.

J7-3, A COM: Analog common reference/return.

J7-4, not used.

J7-5, CT COM: Not used.

J7-6, OSC B: Phase B input oscillator signal. Greater than 10K ohms input impedance, 5.0V rms for full scale voltage, 0.0 volts DC offset, 45 Hz to 5000 Hz input frequency. Use A COM for signal return.

J7-7, A COM: Analog common reference/return.

J7-8, CL B: Make no connection.

J7-9

J7-10, OVR TMP: Over Temperature. This active low open collector output indicates excessive power source heat sink temperature. When active, the power source outputs are disabled.

J7-11, CNF: Make no connection.

J7-12, not used.

J7-13, not used.

J7-14, F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor off to indicate a change of programmed values.

J7-15, EX SYNC LO: External Sync Low signal. This is the LED cathode on the input of an optical isolator. An internal programmable power controller can synchronize its frequency to a 5 volt, 1.5 milliamp, 45 Hz to 5000 Hz signal on the External Sync pins.

J7-16, not used.

J7-17, not used.

J7-18, not used.

J7-19, not used.

J7-20, not used.

J7-21, not used.

J7-22, not used.

J7-23, OSC C: Phase C input oscillator signal. Greater than 10K ohms input impedance, 5.0V rms for full scale voltage, 0.0 volts DC offset, 45 Hz to 5000 Hz input frequency. Use A COM for signal return.

J7-24, OSC A: Phase A input oscillator signal. Greater than 10K ohms input impedance, 5.0V rms for full scale voltage, 0.0 volts DC offset, 45 Hz to 5000 Hz input frequency. Use A COM for signal return.

J7-25, CL C: Make no connection.

J7-26, CL A: Make no connection.

J7-27, D COM: Digital Common. Use this line as the return for logic signals on the system interface connector.

J7-28, RNG HI: Make no connection.

J7-29, Make no connection.

J7-30, not used.

J7-31, F STB HI: Function Sync High signal. This is the collector lead of an optically isolated NPN transistor. The internal power controller turns this transistor off to indicate a change of programmed values. Refer to Function Sync Connections figure.

J7-32, EX SYNC HI: External Sync High signal. This is the LED anode on the input of an optical isolator. An internal programmable power controller can synchronize its frequency to a 5 volt, 1.5 milliamp, 45 Hz to 5000 x pulsed signal on the External Sync pins.

J7-33, not used.

J7-34, not used.

J7-35, not used.

J7-36, REMOTE SHUTDOWN: This 5 volt logic line, when pulled low (to D COM) signals the internal power controller to set the power source output voltages to zero and to open the confidence/output application relays if installed. When the REMOTE SHUTDOWN line is released, the confidence/output application relays are automatically closed, and the output voltages are restored. If the internal power controller's operating language is CIIL, the REMOTE SHUTDOWN input is disabled.

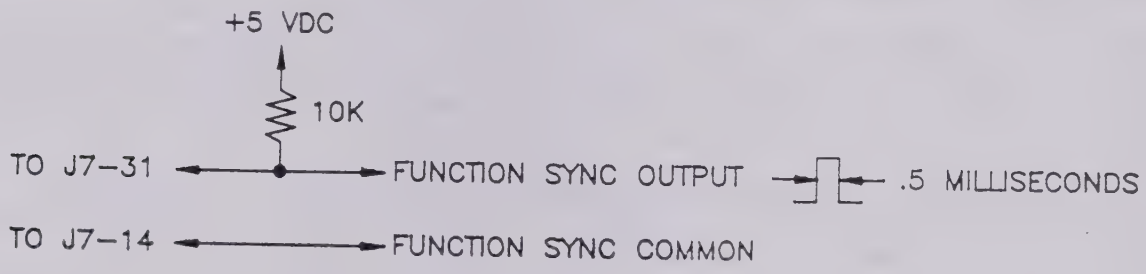
3.4 LOCAL OPERATION

The following sections describe the control of the 1503L from the front panel keyboard as well as from the remote interface, IEEE-488.

The front panel keyboard will be enabled whenever the REMOTE light is extinguished.

The CONTRAST control on the front panel of the 1503L may be adjusted to optimize the viewing angle of the 1503L display.

The 1503L may be manually programmed by using the front panel keyboard and observing the front panel display.



FUNCTION SYNC CONNECTIONS

3.5 KEYPAD

Figure 3-5 shows the front panel keypad. Table 3-1 lists each key and a brief description. While viewing any Output Parameter screen (Ref. Table 3-2), the screens may be viewed in increasing order by depressing the MON key and in decreasing order by depressing the PRG key. While viewing the Measurement Screens, the MON and PRG keys work in a similar fashion.

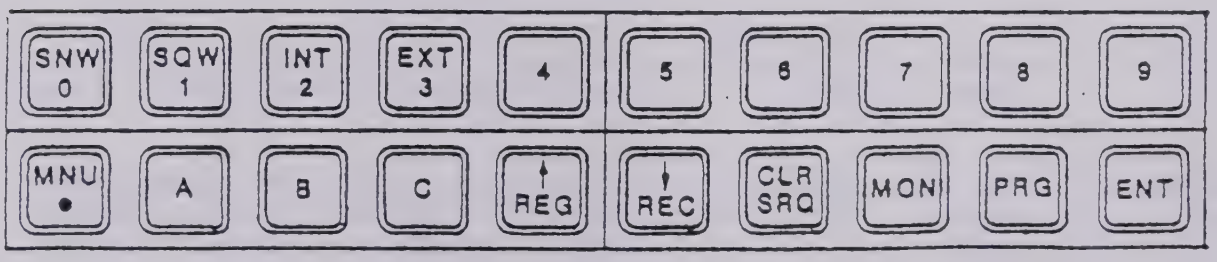


FIGURE 3-5

FRONT PANEL KEYPAD

KEY	DESCRIPTION
SNW/0	Inputs the value "0" for all output parameters or to select screen "0" when followed by the ENT key. Also used to select the sine wave waveform.
SQW/1	Inputs the value "1" for all output parameters or to select screen "1" when followed by the ENT key. Also used to select the square wave waveform.
INT/2	Inputs the value "2" for all output parameters or to select screen "2" when followed by the ENT key. Also used to select the Internal Synchronize or Internal Clock modes of operation.
EXT/3	Inputs the value "3" for all output parameters or to select screen "3" when followed by the ENT key. Also used to select the External Synchronize or External Clock modes of operation.
4 through 9	Inputs the indicated numeric value for all output parameters or to select the corresponding screen when followed by the ENT KEY.
MNU/.	Selects the Menu screens that show all display screens and the corresponding numeric value. The decimal point function of this key is enabled after any numeric key is depressed.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
C	Used to direct any parameter change to phase C. Also used to update any quantity in the display identified as C=.
↑/REG	Used to increment the value in any output parameter screen or calibration screen. Also used to load the program register into any register identified by the preceding numeric value.
↓/REC	Used to decrement the value in any output parameter screen or calibration screen. Also used to recall the program register identified by the preceding numeric value.

TABLE 3-1

KEYPAD KEY DESCRIPTION

KEY	DESCRIPTION
CLR/SRQ	Used to clear the numerical inputs for the display screen.
MON	Used to display programmed output parameter values. Used repeatedly, it will cause the display screens of increasing numeric numbers to be displayed.
PRG	Used to program setup values in the Program Register. Used repeatedly, it will cause the display screens of decreasing numeric numbers to be displayed.
ENT	Used to transfer the contents of the program register to the actual output parameters.

TABLE 3-1 (continued)

KEYPAD KEY DESCRIPTION

3.6 DISPLAY SCREENS

A display of data on the 1503L front panel display is called a screen. The 1503L displays four types of screens: menu, output parameter, measurement and configuration screens.

3.6.1 MENU SCREENS

Menu screens display the screen abbreviation with its equivalent number. The numeric value for each item in a menu screen is the code that may be used to select the screen. Tables 3-2 through 3-4 show the numeric values for all screens. Without the aid of the tables the MNU key may be used.

The menu screens will display only the programmable features that are enabled and their associated screen number.

3.6.2 OUTPUT PARAMETER SCREENS

Table 3-2 shows all of the available Output Parameter screens. The 1503L may not display all of the screens since some program parameters are optional. While viewing any of the screens, the associated output parameter may be changed from the keyboard.

3.6.3 MEASUREMENT SCREENS

Table 3-3 shows all of the Measurement screens. When accessing some Measurement screens up to three seconds may be required to display the screen.

3.6.4 CALIBRATION SCREENS

Table 3-4 shows all of the screens for calibrating the output and measurement functions. A special code is required to access these screens. Refer to Section 4, Calibration.

3.6.5 CONFIGURATION SCREENS

Table 3-5 shows all of the Configuration screens. The only value that is user programmable is the IEEE-488 (GPIB) Listen Address.

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for changing the output:				
1	SNC		IN, EXT	Selects phase A to be synchronized to an external input.
*2	CLK		INT, EXT	Selects the external clock mode of operation.
*3	WVF	A, B, C	SNW, SQW	Sets the output waveform to sine wave or square wave.
4	RNG		Range limit	Selects the output voltage range. Range limit values of 135 and 270 are standard.
5	AMP	A, B, C	0-RNG limit	Sets the output voltage amplitude.
6	FRQ		45-5000	Sets the output frequency.
7	PHZ	A, B, C	0-±999.9	Sets the output phase angle.
8	CRL	A, B, C	0-4.12	Sets the output current limit.
9	RMP A	DLY	0.001-9999	Sets the Delay between ramp steps in seconds. Four decade resolution from 0.001 to 9999 seconds.
		STP		Sets the step size of ramp parameter.
		VAL		Sets the final value of the parameter ramped.
	RMP B	STP		Same as RMPA.
		VAL		Same as RMPA.
28	DRP	A, B, C	0 to 5	Drop periods of sine wave.

*Optional screen.
NOTE: RMPA and RMPB screens are not accessible until AMP, FRQ, CRL or PHZ are programmed (PRG) but not yet entered (ENT).

TABLE 3-2

OUTPUT PARAMETER SCREENS

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for measured values.				
11	ELT	H, M, S	Hrs,Min,Sec	Reports the total accumulated run time up to 9,999 hours.
21	VLT	A, B, C	0-400.0	Measures the TRMS output voltage.
22	CUR	A, B, C	0-40.00	Measures the TRMS output current in Amps.
23	PWR	A, B, C	0-4000	Measures the True output power in watts.
24	PWF	A, B, C	0-1.000	Measures the power factor of the load.
25	APW	A, B, C	0-4000	Measures the apparent output power in VA.
26	FQM		40-5000	Measures the output frequency in hertz.
27	PZM	A, B, C	0-359.9	Measures the phase angle of the output voltage relative to phase A and phase A relative to an external input.

TABLE 3-3

MEASUREMENT SCREENS

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
12	CAL AMP	A, B, C	0-255	Calibrates the programmed output voltage.
13	CAL VLT	A, B, C	Actual output voltage	Calibrates the measured voltage to be the same as argument
14	CAL CUR	A, B, C	Actual output current	Calibrates the measured current to be the same as argument
15	CAL PWR	A, B, C	Actual output power	Calibrates the measured power to be the same as argument
20	POF	A, B, C	0-±359.9	Calibrates the programmed output phase angle.

TABLE 3-4

CALIBRATION SCREEN

SCREEN NO.	NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
16	CFG	A(LSN)	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		B(CFG)	*60	Defines the features enabled for Power Source compatibility.
		C(PHZ)	*120	Defines the phase C initial value for power system configuration.
17	ALM	A(RNG)	0 or 8	Code that defines the default voltage range.
		B(LLM)	*135	Defines the lower voltage range.
		C(HLM)	*270	Defines the higher voltage range.
18	FLM	A(FRQ)	60	Defines the default frequency.
		B(LLM)	*45	Defines the low frequency limit.
		C(HLM)	*5000	Defines the high frequency limit.
19	CLM	A(RNG)	Max Current	Defines the maximum current limit value.
		B(PRS)	*0	Defines the decimal point location for measured power.
		C(CRS)	*2	Defines the decimal point location for measured current.
29	INI	A(AMP)	0-5	Defines default voltage.
		C(CRL)	0 - Max Current	Defines the default Current Limit.

*NOT USER PROGRAMMABLE. THE VALUES SHOWN ARE FOR A STANDARD 3-PHASE SYSTEM.

TABLE 3-5

CONFIGURATION SCREENS

3.7 TO PROGRAM THE OUTPUT

3.7.1 AMPLITUDE

Select the Amplitude (AMP) screen by entering keystrokes:

5 ENT

The display now shows the AMP parameter screen:

```
AMP MON    A = 5.0
B = 5.0    C = 5.0
```

Program all outputs to 115.5 volts with the keystrokes:

115.5 PRG ENT

Program phase A to 130.0, phase B to 110.0 and phase C to 90.0 volts.

130 A PRG 110 B PRG 90 C PRG ENT

Slowly increase the output amplitude of phase B only:

B PRG ↑ (Hold until desired value is obtained.)

3.7.2 FREQUENCY

Select the Frequency (FRQ) screen by entering the keystrokes:

6 ENT

Program the output to 60.23 hertz:

60.23 PRG ENT

To incrementally increase the output frequency to a desired value:

↑ (Hold until desired frequency is reached.)

The output frequency may be programmed down to 17 Hz if the programmed voltage Amplitude (AMP) is less than the full scale voltage range. The low frequency limit can be determined from the following formula:

$$\text{Frequency (Hz)} = \frac{(\textit{Programmed Voltage}) \times .45}{(\textit{Voltage Range})}$$

3.7.3 PHASE ANGLE

Select the Phase (PHZ) screen by entering:

7 ENT

Program phase C to .5 degree relative the phase A:

0.5 C PRG ENT

To enable the External Sync input and to program phase A to 90.0 degrees relative to the External Sync input, perform the following sequence:

1. Select the SNC screen:

   1 ENT

2. Program EXT:

   EXT PRG

At this point the phase screen must be accessed by repeatedly depressing either the MON or PRG keys. After the Phase (PHZ) screen is displayed, enter the following key sequence to simultaneously enable the External Sync and program phase A to 90 degrees:

9 0 A PRG ENT

The up (↑) and down (↓) keys may be used to increment or decrement any or all output phases.

NOTE

The PHZ A value is maintained in nonvolatile memory. The last programmed value is retained at power-up.

3.7.4 CURRENT LIMIT (CRL = 8)

The Current Limit can be programmed independently or simultaneously for each phase of the 1503L. The Current Limit value is in average amps of the absolute value of the current.

1. Select the Current Limit screen by entering:

   8 ENT

2. Program all phases to 2 amps:

   2 PRG ENT

3.7.5 VOLTAGE RANGE (RNG=04)

The RNG screen has two purposes: to select a voltage range and to select an upper voltage limit for the chosen range. Two standard ranges are available and their maximum voltage values are fixed at 135 on the LOW range and 270 on the HIGH range.

The power source controller will automatically set the voltage range to LOW for RNG values programmed to 135 or less. RNG values greater than 135 will cause the HIGH range to be selected.

The value programmed in the RNG screen will also be the maximum value allowed to be programmed in the Amplitude (AMP) screen.

To select the 270 range and set a program amplitude limit of 250 volts, perform the key sequence below:

4 ENT 250 PRG ENT

3.7.6 RAMP OR STEP FUNCTIONS (RMP=9)

The Ramp (RMP) function allows any programmable parameter (AMP, FRQ, PHZ, CAL or CRL) to be Stepped (STP) with a Delay (DLY) for each step to a final value (VAL).

There are three types of programs that may be specified by the RMP screen; a ramp and two types of step programs.

The step function will program the output parameter value specified by a previous screen for the time specified for the DLY value in seconds. The parameter will then return to a final value specified by the VAL value.

The ramp function will step the output parameter value specified by a previous screen with the STP value, the DLY time per step and the final VAL setup in the RMP screen. The ramp will increment if the VAL value is larger than the parameter value. It will decrement if it is less than the parameter value.

NOTE

> The DLY, STP or VAL parameters must be specified (A, B or C key depressed) before the number value for the parameter is entered.

When ramping frequency, an error message will result with an attempt to step the frequency with greater resolution than that possible by the initial or final values. The frequency resolution is four decades.

The step program may also be used to generate a dropout to zero volts on phase A at any point on the waveform. This type of program is selected by setting the AMP value to zero before setting the DLY and VAL parameters. The point on the waveform at which the dropout occurs is specified by setting the A value in the (PHZ) screen.

The following key sequence will program 130V for 2.5 seconds and then return to a final value of 115V.

1. Select the AMP screen and enable 130 volts to be programmed:

   5 ENT 130 PRG (*)

2. Select the RMP screen, program a DLY of 2.5, a final VAL of 115 volts and run the program:

   9 ENT A 2.5 PRG C 115 PRG ENT

The next example will illustrate a ramp program. The following sequence will ramp the frequency from 60 hertz to 400 hertz in .1 hertz steps with a delay (DLY) for each step of .003 seconds. The total time for this ramp will be = [(VAL- FRQ)/STP]DLY or 10.2 seconds.

1. Select the FRQ screen and set the starting frequency of 60 Hz:

   6 ENT 60 PRG

2. Select the RMP screen, set a DLY of .003, set the STP of .1, set the final VAL of 400 and run the program:

   9 ENT A 0.003 PRG B 0.1 PRG C 400 PRG ENT

The following program will illustrate a dropout to zero volts. The program will drop the phase A amplitude to zero volt at 90 degrees for .002 seconds and return to 115 volts.

1. Select the AMP screen and program output to 115 volts:

   5 ENT 115 PRG ENT

2. Select the PHZ screen and program A to 90:

   7 ENT 90 A PRG

(*)If the ENT key is depressed at this point, the AMP would be programmed to and remain at 130 volts.

3. Select the AMP screen and program the dropout voltage to zero volt:

    5 ENT 0 PRG

4. Select the RMP screen. Set a delay of .002 seconds and a return value of 115 volts:

    9 ENT A 0.002 PRG C 115 PRG

5. Execute the program by depressing the ENT key.

Two output parameters may be ramped simultaneously. The parameter programmed just prior to entering the RMP A screen will be the independent parameter and will be identified in that screen. The parameter loaded prior to the independent parameter will be the dependent parameter.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen (dependent parameter) and program the start to 10 volts:

    5 ENT 10 PRG

2. Select the FRQ screen (independent parameter) and program the start frequency of 360 Hz:

    6 ENT 360 PRG

3. Select the RMPA screen and program the independent ramp parameters of STP = .2, and DLY = .2 and VAL = 440:

    9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMPB screen and program the dependent (AMP) ramp parameters of STP = .5:

    10 ENT B 0.5 PRG

5. Start the program by pressing the ENT key.

The final value of the dependent parameter, AMP, will be determined by the number of steps of the independent parameter and the STP value, .5V specified in RMP B.

FINAL VALUE = INITIAL VALUE + (RMP B STP) (NO. STEPS)
NO. STEPS = (DEP. PAR.) (FINAL VALUE - INITIAL VALUE)/STEP SIZE

In this example:

NO. STEPS = (440 - 360)/.2 = 400

FINAL AMP VALUE = 10 + .5 X 400 = 210 Volts

If the final value exceeds the RNG value, an error message will be generated.

NOTE

Any ramp may be terminated at any time by depressing the ENT key.

3.7.7 WAVEFORM (WVF=3)

The WVF screen displays the type of waveform selected, sine wave (SNW) or square wave (SQW), for each of the three outputs. To program a square wave, depress the SQW or any odd number key followed by any combination of the A, B or C key, the PRG key and ENT key. If no phase key is depressed, the new waveform will be programmed for all outputs.

To program phase A and C to square wave:

3 ENT SQW A C PRG ENT

To select the sine wave waveform for any phase depress the SNW or any even number key followed by the key sequence described above.

3.7.8 SYNCHRONIZATION (SNC=1)

The SNC screen displays whether the external or internal SNC mode of operation has been selected.

To select the external SNC mode:

1 ENT EXT PRG ENT

While operating in the EXT SNC mode, the FRQ screen will display the frequency of the External Sync signal. The signal must be between the low frequency limit and 5000 Hz or the High Frequency Limit.

NOTE

When viewing the SNC, CLK or WVF screens, the MON or PRG keys must be used to sequence to another screen. The MNU key can also be used to return to the menu then followed by any screen selection.

To return to the internal SNC mode of operation, depress the INT key or any even numeric key followed by the PRG and ENT key while viewing the SNC screen.

Example: INT PRG ENT

If the External Sync signal is not between the Low Frequency Limit and 5000 Hz, or the High Frequency Limit, an error message will be displayed. See Figure 3-6. In addition, the 1503L will return to the INT mode operation.

*AMP A & B & C FAULT

*TEMP A & B & C FAULT

CPU MEMORY FAULT

DMA OVERFLOW

DIV ERROR

OVERFLOW ERROR

EXT SYNC ERROR

BUS LOCAL ERROR

SYNTAX ERROR

AMP RANGE ERROR

FRQ RANGE ERROR

PHZ RANGE ERROR

CRL RANGE ERROR

RMP RANGE ERROR

*Can be any combination of A, B or C.

FIGURE 3-6

ERROR MESSAGES

In the EXT SNC mode the A value on the PHZ screen represents the angle of the A output leading the External Sync input. If the zero degree point of the power source does not match the zero degree point of the External Sync input, the POF screen may be used for calibration. Select the POF screen and enter a value for calibration.

3.7.9 CLOCK (CLK=2)

The clock selection is an option for the 15031. The CLK screen displays whether the 1503L is operating in the external (EXT) or internal (INT) CLK mode of operation. While viewing this screen to select the EXT CLK mode, depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

NOTE

Before selecting the External clock mode, ensure that the AC Power System has the proper clock and lock signals applied to the BNC connectors on the rear panel. Failure to have the proper clock and lock signals when the EXT CLK mode of operation is selected may result in damage to the power source.

To return to the internal (INT) CLK mode of operation, depress the INT or any even numeric key followed by the PRG and ENT key while viewing the CLK screen.

Example: INT PRG ENT

3.7.10 REGISTERS AND RAMPS

The 1503L has 16 registers that can be used to store setups. All of the data stored in the registers will be retained during power-down. Each 1503L register operation may be chained to another register by adding the REC and register number to any setup sequence.

The REC and REG keys are used for register operations. Any of the previous examples may be stored in a register by adding the extra step of entering the register number followed by depressing the PRG key. This extra step must be entered before the last ENT key-stroke.

The following program will program 135 volts and 60 hertz on all outputs for 10 seconds before reducing the output to 115 volts and store the test in register 0.

1. Select the FRQ screen and program 60 hertz:

   6 ENT 60 PRG

2. Select the AMP screen and program 135 volts:

   5 ENT 135 PRG

3. Select the RMP screen and program DLY = 10 and VAL = 115

9 ENT A 10 PRG C 115 PRG

4. Store the program in register 0:

0 REG

To recall and perform the register operation, simply enter the register number followed by depressing the REC and ENT keys.

3.7.10.1 REGISTER LINKING

Any number of registers may be linked together by using the REC key prior to loading the register operation.

The following program will ramp the voltage from 115 volts and 60 hertz to 135 volts with .1 volts per 10 millisecond steps, remain at 135 volts for 10 seconds, return to 115 volts at the same rate but at 62 Hz. Store the program in Registers 1 and 2.

1. Select the FRQ screen and program 60 Hz:

6 ENT 60 PRG

2. Select the AMP screen and program 115 volts:

5 ENT 115 PRG

3. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 135:

9 ENT A 0.01 PRG B 0.1 PRG C 135 PRG

4. Link this program to Register 2:

2 REC

5. Store this program in Register 1:

1 REG ENT

The second portion of the program will be stored in Register 2.

6. Select the FRQ screen and program 62 Hz:

6 ENT 62 PRG

7. Select the AMP screen and program 135 volts:

5 ENT 135 PRG

8. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 115:

9. Store this program in Register 2:

```
2 REG ENT
```

To initiate the program:

```
1 REC ENT
```

3.7.10.2 SIMULTANEOUS RAMPS

Two outputs may be simultaneously ramped or stepped by enabling two parameter screens. The screen first selected will be the dependent parameter. The last parameter screen selected before entering the ramp (RMP) screen is the independent parameter. The independent parameter is used to specify the number of steps in a ramp. Since the dependent parameter has as many steps as the independent parameter, the step (STP) size must be calculated so the dependent parameter will not exceed its maximum value. The following example will specify frequency as the independent parameter and voltage amplitude as the dependent parameter.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen and specify the starting voltage of 10 volts:

```
5 ENT 10 PRG
```

2. Select the FRQ screen and specify the starting frequency of 360 Hz.

```
6 ENT 360 PRG
```

3. Select the RMP A screen and specify the ramp parameters of the independent parameter, FRQ, of DLY = .2 seconds, STP = .2 Hz and VAL = 440 Hz:

```
9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG
```

4. Select the RMP B screen and specify the ramp parameter of the dependent parameter, AMP, of STP = .5 volts:

```
10 ENT B 0.5 PRG
```

5. At this point the program may be executed by depressing the ENT key or stored in a register.

3.7.11 TO PROGRAM THE DROP PERIODS (DRP=28)

Select the phase (PHZ) screen by entering the keystrokes:

7 ENT

The display will show the PHZ parameter screen

PHZ MON A = 0.0 B = 240.0 C = 120.0

To drop the output waveform starting at 90 degrees, enter the keystrokes 90 A PRG.

Select the Drop screen (DRP=28) by entering the keystrokes 2 8 ENT.

The display will show the DRP parameter screen.

DRP MON A = 0 B = 0 C = 0

To drop the output waveform for phase A for 3 cycles enter the keystrokes:

3 A PRG ENT

Verify that phase A drops at the 90 degrees point of the sine wave for 3 periods of the programmed frequency.

3.7.12 TO PROGRAM FREQUENCY, VOLTAGE, VOLTAGE RANGE AND CURRENT LIMIT DEFAULT VALUES

The default values are the values that appear at power-up and after the GPIB Device Clear command.

To set any of the default values, perform the following steps:

1. Depress the MNU key several times until the first menu screen is displayed as illustrated below:

   SNC = 01 *CLK = 02
   *WVF = 03 RNG = 04

   NOTE (*) may not be displayed. Depends on options.

2. Enter the key sequence: 9 5 9 ENT

3. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

   CFG = 16 ALM = 17
   FLM = 18 CLM = 19

To program the default frequency, enter the key sequence:

1 8 ENT A

next enter the default frequency followed by depressing the PRG and ENT key.

To program the default voltage range, perform step 1 through 3. Next enter the key sequence:

1 7 ENT A

At this point, if 0 is entered, the default is the Low Voltage Range.

If an 8 is entered, the default voltage range will the High Range.

To make the High Range the default, continue the key sequence with:

8 PRG ENT

To program the default voltage, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT A

At this point the default voltage from 0 to 5 may be entered. If a value of less than 5 volts is entered, the output may fault when a voltage is programmed to a value that is less than 50% of full scale.

To make 5 volts the default voltage, continue the key sequence with:

5 PRG ENT

To program the default current limit, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT C

At this point, any value may be entered up to the maximum current available per phase.

To make 5 amps the default value, continue the key sequence with:

5 PRG ENT

3.8 TO MEASURE THE OUTPUT

Six of the measurement screens display the phase A, B and C outputs simultaneously. These six screens are for voltage, current, power, apparent power, power factor and phase. The measurement screen for frequency displays the same value for all three phases.

While viewing any measurement screen, any other measurement screen may be displayed by repeatedly depressing either the MON or PRG key.

The screen may also be displayed by entering its equivalent screen number followed by depressing the ENT key. Refer to Table 3-3 for all measurement screen numbers.

3.8.1 VOLTAGE (VLT=21)

The voltage screen displays the actual TRMS output voltage with 0.1 volt resolution. This voltage is the voltage at the Remote Sense connector of the 1503L.

To access the voltage screen, depress the keys:

21 ENT

3.8.2 CURRENT (CUR=22)

The current screen displays the actual TRMS load current. The resolution is 0.01 amp.

3.8.3 POWER (PWR=23)

The power screen displays the actual true power delivered to the load. The resolution is 1 watt.

3.8.4 POWER FACTOR (PWF=24)

This screen displays the power factor from 0 to 1.000 with 0.001 resolution. The PWF screen will read unity for loads less than 10 watts on the Power (PWR) screen. When this screen is displayed after another screen, it takes approximately two seconds to update the screen.

3.8.5 APPARENT POWER (APW=25)

This screen is accessed by its screen number, 25. It displays VOLT-AMPERES with a resolution of 1 VA.

3.8.6 FREQUENCY (FQM=26)

This screen is accessed by its screen number, 26. It displays the output frequency with a resolution of 0.01 Hz, 0.1 Hz or 1 Hz up to 99.99 Hz, 999.9 or 5000 Hz, respectively.

3.8.7 PHASE ANGLE (PZM=27)

This screen is accessed by its screen number, 27. It displays phase A relative to an external synchronizing input and phase B and C relative to phase A. The resolution is 0.1 degree.

3.8.8 ELAPSED TIME (ELT =11)

This screen displays the total run time accumulated on the 1503L up to 99,999 hours.

H = Hours M = Minutes S = Seconds

3.9 REMOTE PROGRAMMING WITH ABBREVIATED PLAIN ENGLISH (APE)

Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alphanumeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-6.

These abbreviations must not be confused with the device dependent abbreviations used to describe the AC Power System operating parameters (ex. FRQ=Frequency, etc.).

3.10 UNIT ADDRESS

This is the A value (LSN) set in the CFG screen. The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-11 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1 but may be changed by selecting the CFG Configuration screen and setting a new value.

To select the CFG screen repeatedly depress the MNU key until menu screen #1 is displayed as illustrated below:

```
 SNC = 01
*WVF = 03      RNG = 04
```

Enter the key sequence: 959 ENT

Repeatedly depress the MNU key until the menu screen #5 is displayed as illustrated below:

```
CFG = 16       ALM = 17
FLM = 18       CLM = 19
```

Enter the key sequence: 16 ENT

NOTE (*) WVF is an optional screen.

TABLE 3-6
COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states..
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End or Identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to local when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to it Power-on state.

Table 3-7
Unit Address Group.

LISTEN ADDRESS	HEX	BINARY						DECIMAL	ASCII
			A5	A4	A3	A2	A1		
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	'
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

The CFG screen will now be displayed. Depress the A key to display the present Unit Address. It may be changed to any value from 0 to 30 and will be stored in non-volatile memory. The new unit address will not be updated until power is shut off and reapplied to the power system.

The following key sequence will change the unit address to 16:

16 PRG ENT

3.11 MESSAGE FORMAT

The message sent to the 1503L must have the following format for each parameter:

HHHDXXX----------------E±NND

where

H = Three letter mnemonic for each message header
D = Optional header extension to specify output (ref. table 3-5)
X = Alpha or numeric argument or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter. (CR) (LF) or (LF)

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

The ASCII # symbol is used in a ramp program to designate that the start of the ramp is the existing output value. This feature is useful when remotely calibrating the 1503L without knowing the existing CAL coefficient.

3.11.1 NUMERIC DATA FIELD

Parameter values may be sent to the 1503L as an unsigned value with a decimal point or a decimal point with an exponent. Phase may be sent as a signed value.

The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts to the Model 1503L.

```
AMP115
AMP115.0
```

There may be any number of digits following the decimal point, not to exceed the 256 byte DMA buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is tenths of volts. The LSD for frequency is either hundredths, tenths or Hertz for up to 99.99 Hz, 999.9 Hz or 9999 Hz respectively.

Any parameter's numeric value may be of a mixed form with a decimal point and exponent.

The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 115 volts to the 1503L:

```
AMP1.15E2
AMP1.15E+2
AMP1.15E+02
AMP1150E-1
```

A positive exponent value is represented by either an ASCII "+" or an unsigned value.

3.11.2 PROGRAM HEADERS

A Program Header is a mnemonic of a series of three ASCII characters used to select an 1503L function or identify the data it precedes. The header is an abbreviation of the program function it identifies.

The header may be followed by a header extension to separately program each output (phase A, B or C) to different values. If an extension is not added to the header all outputs will be programmed to the header's argument. See Table 3-8 for the definition of the Program Headers and their related arguments.

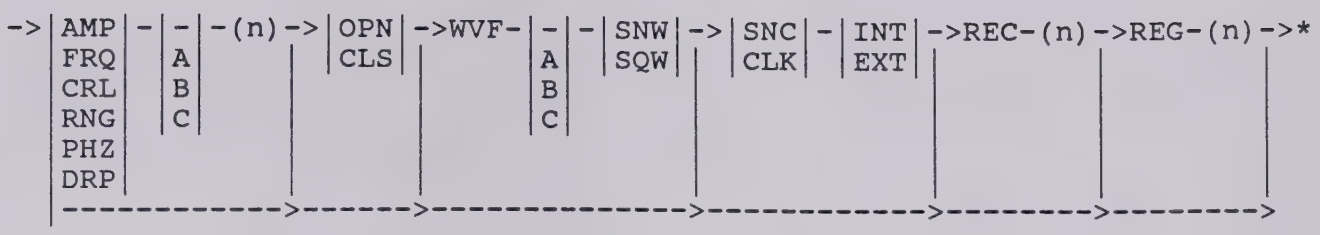
Any header that is sent to the 1503L without an argument will cause the front panel display to show the corresponding screen.

The program header extension works on the trailing exception rule. This characteristic can be used to shorten the setup string. The following example demonstrates the trailing exception rule by programming the phase A and B outputs to the square wave waveform and phase C to a sine wave.

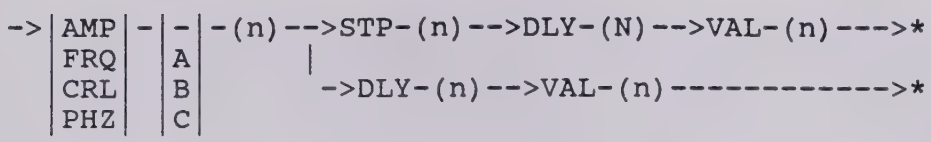
```
WVF SQW WVF C SNW
```

Refer to Figure 3-7 for a summary of all possible APE command sequences.

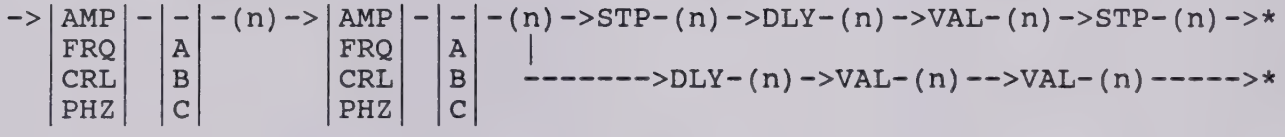
TO PROGRAM OUTPUT PARAMETERS:



TO RAMP OR STEP ONE OUTPUT PARAMETER:



TO RAMP OR STEP TWO OUTPUT PARAMETERS:



TO REQUEST TALKING OF CALIBRATION COEFFICIENTS:

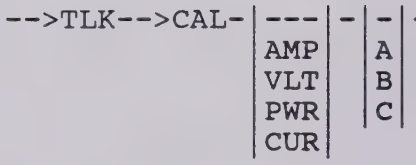
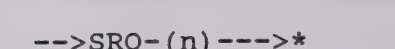


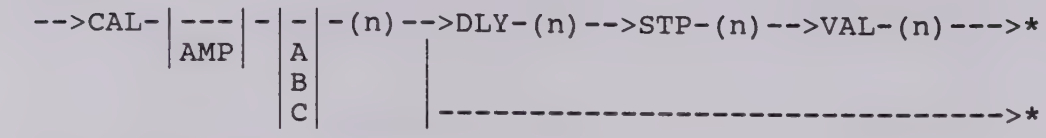
FIGURE 3-7

REMOTE COMMAND SEQUENCES

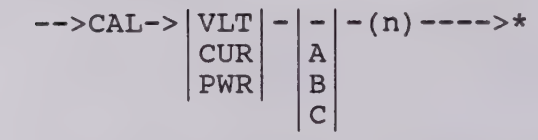
TO SPECIFY THE SERVICE REQUEST INTERRUPT:



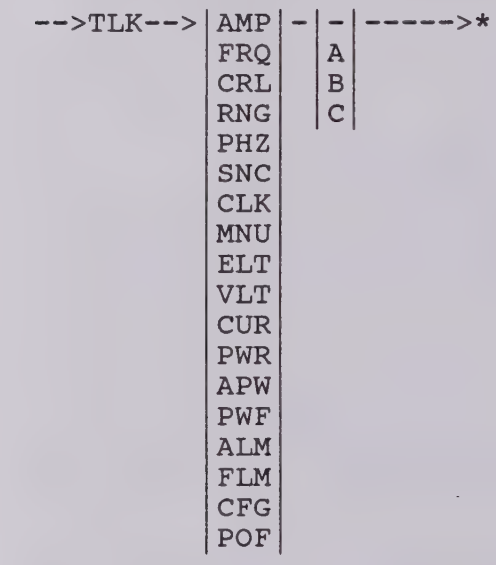
TO CALIBRATE OUTPUT:



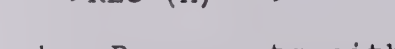
TO CALIBRATE MEASUREMENT:



TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:



TO RECALL A REGISTER:



* Represents either an IEEE-488 END or EOS message. The EOS message may be either an ASCII Carriage Return(CR), Line Feed(LF) or just LF.

n Represents a numeric value.

FIGURE 3-7 (continued)

REMOTE COMMAND SEQUENCES

TABLE 3-8

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
AMP	A, B, C	# or numeric from 0.0 to RNG value.	Amplitude in volts.
CAL or CAL AMP	A, B, C	# or numeric data from 0.0 to 255	Calibration Coefficient for output voltage.
CAL VLT	A, B, C	Expected	Actual voltage at remote sense.
CAL CUR	A, B, C	Expected	Actual current from power source.
CAL PWR	A, B, C	Expected	Actual power from power source.
CLK		INT, EXT	Clock source.
CRL	A, B, C	Numeric value 0.00 to 100.0 (maximum current of system)	Current limit in amps.
DLY		Numeric data from 0.00 to 9999	Delay in seconds.
DRP	A, B, C	1 through 5	Number of drop periods.
FRQ		Numeric data from 45.00 or LLM to HLM value	Frequency in hertz. May be down to 17 Hz at reduced voltage.
PHZ	A, B, C	# or numeric data from 0.0 to ±999.9	Phase angle in degrees.
PRG		0 through 16	Register load.
REC		0 through 16	Recall register.

TABLE 3-8 (cont.)

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
REG		0 through 15	Register load.
RNG	A, B, C	0.0 to limit value of range	Amplitude range and limit value in volts.
SNC		INT, EXT	Synchronize
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program.
STP		From parameter minimum to maximum value.	Step size.
TLK		Any program header or other argument	Set up 1503L to talk argument when talk addressed.
TRG			Execute (Trigger) set-up parameters on GPIB 'GET" message.
VAL		From parameter minimum to maximum value.	Final ramp or step value in volts, hertz, amps, degrees, sine wave or square wave.
WVF	A, B, C	SNW, SQW	Waveform.
OPN			Open output relays.
CLS			Close output relays.
VLT	A, B, C,		Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
CUR	A, B, C		Used with TLK to request measurement of the output load current.

TABLE 3-8 (cont.)

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
PWR	A, B, C		Used with TLK to request measurement of the True output power.
APW	A, B, C		Used with TLK to request measurement of the Apparent output power.
PWF	A, B, C		Used with TLK to request measurement of the output power factor.
PZM	A, B, C		Used with TLK to request measurement of the output phase angle.
FQM			Used with TLK to request measurement of the output frequency.

NOTE: If the Extension does not follow the header, the argument will be applied to all phases.

3.11.3 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP)

The AMP header with the optional A, B or C extension is used to identify the amplitude command. The argument is a numeric data field from 0.0 to the limit set by the RNG value. An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB.

The following ASCII strings will program the voltage given in the left column:

A,B,C 0.0 volts	AMP0	or	AMPA0AMPB0AMPC0		
A,B,C 10.5 volts	AMP10.5	or	AMP1.05E1	or	AMP105E-1
A,B,C 100 volts	AMP100	or	AMP100.0	or	AMP1E2
A,B = 110.5, C = 115	AMPA110.5AMPB110.5AMPC115 or AMP110.5AMPC115				

3.11.4 TO PROGRAM FREQUENCY (FRQ)

The FRQ header is used to identify the following numeric data as frequency.

The following string will program the frequency to 60.56 Hz.

```
FRQ 60.56
```

3.11.5 TO PROGRAM PHASE (PHZ)

The PHZ header with the optional A, B or C extension is used to identify the following numeric data as phase.

The PHZ header sent with no extension will program the B and C outputs in phase with phase A. The phase of the A output will lead the EXT SNC signal or EXT lock and clock signal by the value programmed.

The following example will program the A, B and C outputs to 90 degrees relative to an external sync signal when operating in the EXT SNC mode:

```
PHZ 90
```

The following example will program phase B to 240.5 degrees and phase C to 119.3 degrees leading phase A.

```
PHZB 240.5 PHZ C 119.3
```

3.11.6 TO PROGRAM CURRENT LIMIT (CRL)

The CRL header with the optional A, B or C extension is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to the maximum rated current of the power system.

The following string will program a current limit of 2.5 amps for all three phases:

```
CRL 2.5
```

3.11.7 TO PROGRAM CALIBRATION (CAL)

The CAL header when used alone or followed by the header AMP, in addition to an A, B or C extension, is used to calibrate the programmed output voltage. The argument is a relative starting coefficient from 0 to 255 or the ASCII # symbol. The CAL ramp is terminated with the GPIB message Group Execute Trigger (GET).

A CAL coefficient can be programmed without a ramp by using only the argument with the CAL header.

To program the CAL A coefficient to 55 use the following string:

```
CALA55
```

To calibrate phase A at 135.0 volts, start the CAL routine with a GPIB GET message with the CAL coefficient starting at 20 and with each step lasting 2 seconds use the following string:

```
AMP135.0 CALA20 DLY2 STP1 VAL255 TRG
```

In this example the output will program to 135.0 and start to change the output by stepping the CAL value after a "GET" message. The ramp will terminate after a second "GET" message.

To calibrate phase A at 135 volts and start the ramp with the existing CAL coefficient reducing the output with steps lasting one second:

```
AMP135.0 CALA# DLY1 STP1 VAL0
```

Again the ramp must be terminated with the bus "GET" message when the external AC calibration DVM indicates the correct voltage.

The CAL header is used with the headers VLT, CUR and PWR to calibrate the respective measurement function. An A, B or C extension follows the headers to designate a specific measurement channel. If the extension is omitted, the calibration coefficients for all measurement channels will be the same and will depend on only the value for phase A. The argument is a numeric value that represents the expected measured value. It should be equal to an external precision TRMS voltmeter, ammeter or power meter.

The following ASCII string will cause the current measurement for phase A to measure the value indicated by a TRMS ammeter standard, 2.56 amps:

```
CAL CUR A 2.56
```

3.11.8 TO PROGRAM RAMP OR STEP OPERATIONS

The DLY header is used with a parameter that has a numeric argument (ex. AMP, FRQ, PHZ, CRL, CAL) in a single step program.

The numeric argument is in seconds with four decade resolution from 0.001 to 9999 seconds.

The STP header with VAL may be used with DLY to completely specify a ramp program.

The following string will first step the voltage to 125 volts for 2.55 seconds and return to 115 volts.

```
AMP 125 DLY 2.55 VAL 115
```

The following string will ramp the voltage from 10 volts to 115 volts with 1.5 volt/.5 sec. steps:

```
AMP 10 DLY .5 STP 1.5 VAL 115
```

When an AMP header with an argument of 0 is used, the waveform will stop and drop to zero volts at the point specified by the PHZ A value.

The following ASCII string will stop the waveform at 0 degrees for .01 seconds and return to 115 volts:

```
PHZ A 0 AMP 0 DLY .01 VAL 115
```

Refer to paragraph 3.7.6 and 3.7.10 for additional information.

The STP header is used to identify the following argument numeric value as the increment or decrement value for a FRQ, CRL, AMP, PHZ or CAL ramp. Refer to paragraphs 3.7.6 and 3.7.10 for additional information.

The following example will ramp all outputs from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

```
AMP130 DLY.5 STP1.5 VAL10
```

The header VAL is used to identify the following numeric argument as the final Value of a ramp or step.

If the VAL argument is larger than the initial value for the parameter to be ramped, the ramp will increment with step size defined by STP and DLY. With the VAL argument less than the initial value, the ramp will decrement from the initial parameter. Refer to paragraphs 3.7.6, 3.7.10, 3.11.2.6.1 and 3.11.2.6.2 for additional information.

A ramp or step operation can be stopped at anytime by the GPIB message Group Execute Trigger (GET).

The following example will decrement the output amplitude of phase A only from 120 in .1 volt/.2 sec steps to 100 volts after a Device Trigger.

```
AMP A 120 DLY.2 STP.1 VAL100 TRG
```

The following example will simultaneously ramp the Frequency from 400 to 5000 Hz at a rate of 10 Hz per second and the Amplitude from 5 volts in increments of .5 volts per step:

```
RNG270 AMP5 FRQ400 STP10 DLY1 VAL5000 STP.5
```

A GPIB Service Request will be generated at the end of a ramp if SRQ2 is included in the setup string.

3.11.9 TO PROGRAM A REGISTER (REG)

The REG header is used to load the register specified by the following numeric data with the preceding data. The numeric value is from 0 to 15. The PRG header is interchangeable with the REG header.

The following example will load a ramp program that will step the voltage from 10 to 115 volts with 1 volt/.5 sec steps at 400 Hz into register 0.

```
FRQ400 AMP10 DLY.5 STP1 VAL115 REG0
```

3.11.10 TO RECALL A REGISTER (REC)

The REC header is used to recall previously loaded data from a register identified by the following register number (0 to 15).

The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3.11.9.

```
REC0
```

The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" message.

```
REC0 TRG
```

The following is an example of register linking. The voltage and frequency is maintained at 115 volts and 60 Hz for 5 seconds and then the program contained in register 0 is recalled and executed. The program is stored in register 1.

```
FRQ60 AMP115 DLY5 VAL115 REC0 REG1
```

The program is initiated by the following ASCII string:

```
REC1
```

3.11.11 TO PROGRAM VOLTAGE RANGE (RNG)

The RNG header is used to select an output voltage range and to set an amplitude programming limit for the range. Two standard voltage ranges are available and their maximum voltage values are fixed at 135 on the LOW range and 270 on the HIGH range. The power controller will select the LOW range for RNG values of 135 or less. RNG values higher than 135 will cause the HIGH range to be selected.

The values programmed by the RNG header will also be the maximum value allowed to be programmed by the AMP, amplitude, header.

If the range and voltage amplitude are to be programmed by the same data string the RNG header and argument must precede the AMP header or a syntax error will be generated.

The following example will select the 270 range from the 135/270 range pair with an upper amplitude limit of 210 volts.

```
RNG210
```

3.11.12 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC)

The SNC header is used with the EXT argument to synchronize the phase A output to an external sync input. The phase A output will be phase referenced to the sync input with the displacement equal to the PHZ A value.

The following ASCII string will program the phase A output to 0 degrees relative to the external sync input.

```
PHZA0 SNC EXT
```

Sending the ASCII string SNC INT will disable the sync input.

3.11.13 TO PROGRAM EXTERNAL CLOCK (CLK) (optional)

The CLK header has an argument of either EXT or INT. The CLK header with the EXT argument will make the 1503L a slave to another compatible system. The slave 1503L will operate at the same frequency as the master system. Phase A of the slave will be related to phase A of the master by the PHZ A value of the slave.

NOTE

The clock option is only available for the 1503L if the LK option has been installed in the power source.

The following ASCII string will enable the CLOCK and LOCK inputs to the 1503L:

```
CLK EXT
```

NOTE

If there is no signal at the CLOCK input at the rear panel of the 1503L, the output will go to zero volts.

The ASCII string CLK INT will return the 1503L to its programmed frequency.

3.11.14 TO TRIGGER AN OPERATION (TRG)

The TRG header has no argument. When the TRG mnemonic is included in a setup string to the 1503L, it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller.

The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The 1503L will then execute the setup values in the remote mode when the Device Trigger is received.

The following example will recall the parameters from register 0 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters.)

```
REC0 TRG
```

3.11.15 TO PROGRAM THE OUTPUT WAVEFORM (WVF) (Optional)

The header WVF with the optional A, B or C extension is used to identify the following argument as the Sine Wave (SNW) or Square Wave (SQW) function of the Waveform.

The following example will program all outputs to the square wave function.

```
WVF SQW
```

The following example will program only output B to the square wave function:

```
WVFB SQW
```

3.11.16 TO OPEN (OPN) AND CLOSE (CLS) THE OUTPUT RELAY

The OPN and CLS headers open and close the optional output relays in the power source. There is no argument associated with these headers.

When the OPN or CLS header is received by the 1503L the output voltage will drop to zero volts for 50 milliseconds while the output relays switch.

3.11.17 TO PROGRAM DROP CYCLE (DRP)

The DRP header is used to identify the Drop Command. The argument is a numeric data field from 1 to 5. The following string will drop the output voltage for Phase B for five complete cycles and start a 0 degree of the waveform.

```
PHZ 0 DRP B 5
```

3.11.18 TO PROGRAM THE DEFAULT FREQUENCY (FLM A)

The default frequency is the output frequency after power-up or after and IEEE-488 Device Clear.

The following example will program the default frequency to 400 Hz:

```
FLM A 400
```

3.11.19 TO PROGRAM THE DEFAULT OUTPUT VOLTAGE (INI A)

The default voltage is the output voltage after power-up, IEEE-488 Device Clear or an Amplitude Fault.

The following example will program the default voltage to 5 volts.

```
INI A 5
```

NOTE

If the default voltage is programmed to a value less than 5 volts, the settling time will increase. In addition, there may be an amplitude fault when the voltage is programmed from the default voltage to a value less than 50% of full scale.

3.11.20 TO PROGRAM THE DEFAULT CURRENT LIMIT (INI C)

The default current limit is the value after power-up or IEEE-488 Device Clear.

The following example will program the default current limit to 10 amps.

```
INI C 10
```

3.11.21 TO PROGRAM THE DEFAULT VOLTAGE RANGE (ALM A)

The default voltage range is the voltage range after power-up or IEEE-488 Device Clear. A value of 0 designates the low range. A value of 8 designates the high range.

The following example will program the default voltage range to the high range.

```
ALM A 8
```

3.11.22 TO TALK (TLK) MEASURED AND PROGRAMMED DATA

The TLK header is used to set up the 1503L to talk data. When the TLK header has a program output parameter as its argument, the 1503L will report its programmed output value for the argument. Table 3-9 is the list of all arguments for the TLK header.

Table 3-10 shows an example response for all TLK arguments with no A, B or C extension.

3.11.23 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK VLT)

VLT may be used as an argument to the header TLK with an A, B or C extension.

When used as an argument, it will set up the 1503L to measure the output voltage with 0.1 volt resolution.

When VLT is used as a header in a string with no argument, it will cause the 1503L front panel to display the measured output voltage.

3.11.24 TO TALK THE MEASURED OUTPUT CURRENT (TLK CUR)

CUR may be used as an argument to the header TLK with an A, B or C extension.

When used as an argument, it will set up the 1503L to measure the output current in amps with 0.01 amp resolution.

When CUR is used as a header in a string with no argument, it will cause the 1503L front panel to display the output current.

TABLE 3-9

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA	DEFINITION
ALM		RNG,LLM,HLM	Amplitude limit screen contents
APW	A, B, C	VA	Measured Apparent Power output
CFG		LSN,CFB,PHZ	CFG screen contents including IEEE-488 listen address
CUR	A, B, C	Current in Amps	Measured current.
ELT		H, M, S	Total accumulated time.
FLM		FRQ,LLM,HLM	Frequency limit screen contents
FQM		Hertz	Measured Output Frequency
INI	A, C		Default Voltage and Current Limit
PZM	A, B, C	Degrees	Measured output phase angle
CAL AMP	A, B, C	0 to 255	Calibration Coefficient
CAL CUR	A, B, C	0 to 255	Calibration Coefficient
CAL VLT	A, B, C	0 to 255	Calibration Coefficient
CAL PWR	A, B, C	0 to 255	Calibration Coefficient
POF	A, B, C	degrees	Programmed phase calibration coefficients
PWF	A, B, C	0.000 to 1.000	Measured power factor
PWR	A, B, C	watts or kilowatts	Measured power output
VLT	A, B, C	Voltage in volts	Measured output voltage
ANY PROGRAM HEADER			Programmed value of the Argument

NOTE: If an A, B or C extension follows the TLK argument (ex. VLT), the response string will contain only the corresponding data.

TABLE 3-10

EXAMPLE TALK STRING RESPONSE

TLK STRING SENT TO 1503L	RESPONSE FROM 1503L AFTER ADDRESSED TO TALK		
TLK ALM	ALMA000	B135.0	C270.0
TLK AMP	AMPA005.0	B005.0	C005.0
TLK APW	APWA0000	B000	C0000
TLK CAL	CALA0155	B0188	C0183
TLK CFG	CFGA0001	B0028	C0120
TLK CLK	CLK INT		
TLK CRL	CRLA4.120	B4.120	C4.120
TLK CUR	CURA00.04	B00.15	C00.16
TLK ELT	ELTH0052	M0027	S0010
TLK FLM	FLMA0400	B0045	C5000
TLK FRQ	FRQ400.0		
TLK FQM	FQM399.9		
TLK INI	INIA005		C4.120
TLK PHZ	PHZA090.0	B240.0	C120.0
TLK PWR	PWRA0.000	B0.000	C0.000
TLK PWF	PWFA1.000	B1.000	C1.000
TLK PZM	PZMA000.0	B240.0	C119.9
TLK REG O	ACTUAL	CONTENTS OF	REGISTER
TLK SNC	SNCINT		
TLK VLT	VLTA004.9	B004.9	C005.0
TLK WVF	WVFA SNW	B SNW	C SNW

NOTE: If an A, B or C extension follows the TLK argument (ex. VLT), the response string will contain only the corresponding data.

3.11.25 TO TALK THE MEASURED OUTPUT POWER (TLK PWR)

PWR may be used as an argument to the header TLK with an A, B or C extension.

When used as an argument, it will set up the 1503L to measure the output power in watts with 1 watt resolution.

When PWR is used as a header in a string with no argument, it will cause the 1503L front panel to display the output power.

3.11.26 TO TALK THE MEASURED OUTPUT POWER FACTOR (TLK PWF)

PWF may be used as an argument to the header TLK with an A, B or C extension.

When used as an argument, it will set up the 1503L to measure the output power factor from 0 to 1.000.

When PWF is used as a header in a string with no argument, it will cause the 1503L front panel to display the output power factor.

3.11.27 TO TALK THE MEASURED OUTPUT APPARENT POWER (TLK APW)

APW may be used as an argument to the header TLK with an A, B or C extension.

When used as an argument, it will set up the 1503L to measure the Apparent Power output in VA with 1 VA resolution.

When APW is used as a header in a string with no argument, it will cause the 1503L front panel to display the measured output Apparent Power.

3.11.28 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)

FQM may be used as an argument to the header TLK. There is no extension for this argument.

When FQM is used as an argument, it will set up the 1503L to measure the output frequency in hertz.

When FQM is used as a header, it will cause the 1503L front panel to display the measured output frequency.

3.11.29 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM)

PZM may be used as an argument with an extension A, B or C for the header TLK.

When used as an argument, PZM will set up the 1503L to measure the phase angle of phase B and C relative to phase A. The measurement is made at the Remote Sense terminals. Phase A is measured relative to an External Sync input.

When PZM is used as a header, it will cause the 1503L front panel to display the phase measurement screen.

3.11.30 MESSAGE SEPARATORS

A complete message consists of a header and an argument. Since more than one message can be sent in a setup string, message separators included in the string between the message will make it more readable to the human operator. There are three message separators recognized by the 1503L: the comma (,), semicolon (;) and a space. Since these separators are ignored by the 1503L, they may be dispersed throughout a setup string.

The following are two examples of the use of separators:

```
FRQ400;AMPA100,AMPB110,AMPC120;WVF SQW

FRQ400;AMP,A,100;AMP,B,110;AMP,C,120;WVF,SQW
```

3.11.31 SERVICE REQUEST

After power-up the GPIB Service Request (SRQ) will be generated by the 1503L after any error (syntax, output fault, etc.). This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1. Sending SRQ2 to the 1503L causes an SRQ to be generated after the execution of a setup string. The setup string can be of any type: ramp, calibration, etc.

The following example disables the 1503L GPIB SRQ.

```
SRQ0
```

After the generation of an SRQ, the status byte may be read from the 1503L. Refer to paragraph 3.11.32

3.11.32 SERIAL POLL STATUS BYTE

Once the bus controller has detected the SRQ, it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. The Status Byte values for various faults are given in Table 3.11.

3.11.33 END OF STRING

The End of String (EOS) delimiter recognized by the 1503L is the ASCII Line Feed (LF). Carriage Return (CR) followed by Line Feed may also be used for EOS. The End or Identify (EOI) IEEE-488 message END will also be recognized.

The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

3.11.34 ERROR MESSAGES

Table 3-11 shows all of the possible error messages than can be generated by the AC Power System. These messages will also be displayed on the front panel of the AC Power System.

3.11.35 GROUP EXECUTE TRIGGER

The trigger mode of the 1503L is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected by the 1503L, it will delay execution of the new setup values until it receives a GPIB Device Trigger or an additional valid setup string.

The trigger mode may also be enabled in the local control mode by programming parameter values without depressing the ENT key. The Model 1503L will then execute the setup values in the remote mode when the Device Trigger is receive.

The following setup string will recall the values from register 9 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. See Table 3-6.)

```
REC9TRG
```

To set up 0 volts, 400 Hertz and wait for GET:

```
FRQ400AMP0TRG
```

TABLE 3-11

STATUS BYTE VALUES

SRQ 1	SRQ 0	REPORTED MESSAGE	CAUSE
64	0	AMP A FAULT	Overload or sense line fault
65	1	AMP B FAULT	Overload or sense line fault
66	2	AMP AB FAULT	Overload or sense line fault
67	3	AMP C FAULT	Overload or sense line fault
68	4	AMP AC FAULT	Overload or sense line fault
69	5	AMP BC FAULT	Overload or sense line fault
70	6	AMP ABC FAULT	Overload or sense line fault
71	7	CRL FAULT	Output current exceeds program value
72	8	TEMP A FAULT	Amplifier overtemperature
73	9	TEMP B FAULT	Amplifier overtemperature
74	10	TEMP AB FAULT	Amplifier overtemperature
75	11	TEMP C FAULT	Amplifier overtemperature
76	12	TEMP AC FAULT	Amplifier overtemperature
77	13	TEMP CB FAULT	Amplifier overtemperature
78	14	TEMP ABC FAULT	Amplifier overtemperature
90	26	RNG RANGE ERROR	RNG value greater than highest range
91	27	AMP RANGE ERROR	AMP value greater than RNG value
92	28	FRQ RANGE ERROR	FRQ value is less than 45 or greater than 5000 Hz
93	29	PHZ RANGE ERROR	PHZ value greater than ±999.0
94	30	CRL RANGE ERROR	CRL value greater than maximum value
95	31	RMPA RANGE ERROR	DLY, STP or VAL values wrong
96	32	SYNTAX ERROR	Wrong string SYNTAX
97	33	BUS LOCAL ERROR	Remote message sent while in local mode
98	34	EXT SYNC ERROR	No external sync input or signal not between 45 and 5000 Hz
99	35	CPU MEMORY FAULT	CPU failed self-test
100	36	DMA OVERFLOW ERROR	Remote message greater than 256 bytes
63			The response after SRQ2 is included in a setup string and the execution of the string or measurement is completed.
	40	STA OK	No problems

3.12 REMOTE OPERATION WITH MATE CIIL

When the 1503L is configured to operate with CIIL as the principal language, the alternate language is APE. Refer to Section 4 for information on the APE program syntax. Using CIIL, the 1503L will accept OP codes, the noun ACS (AC SIGNAL) and noun modifiers to program the operating parameters of voltage, frequency, phase and current limit in a setup string. In addition, a number of OP codes cause the 1503L to perform a specific task such as reset and confidence testing. Figure 3-8 is a summary of the CIIL program syntax.

3.12.1 CIIL ELEMENTS

The Control Interface Intermediate Language (CIIL) elements are:

OP-CODES:	FNC, SET, SRX, SRN, CLS, OPN, RST, CNF, IST, INX, FTH, STA, GAL
NOUN:	ACS
NOUN MODIFIERS:	VOLT, FREQ, PANG, CURL, SYNI, POWR, APOW, CURR, TRSC
CHANNEL DESIGNATORS	:CH00, :CH01, :CH02, :CH03

The only noun recognized by the 1503L is ACS for AC Signal. The only non-operational code (no-op) in a string is an ASCII space. Numeric expressions may be represented by explicit decimal values (e.g., 115.0) or exponential values (e.g., 0.115E3). The exponent field may be either a one-digit or two-digit form (e.g., E1 or E01) signed or unsigned with a range from E-24 to E+24.

STIMULUS STRING

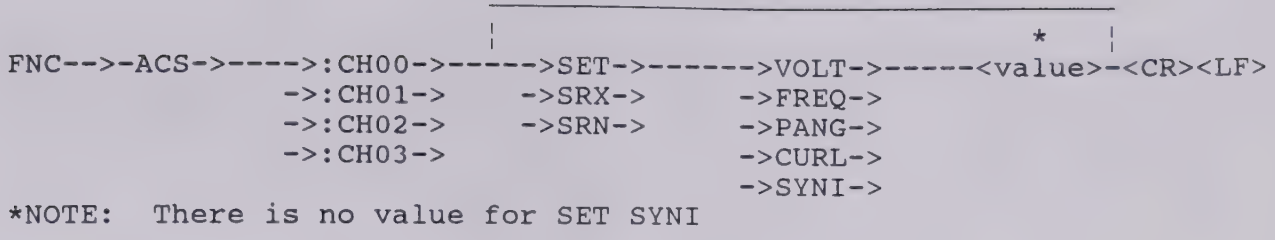


FIGURE 3-8

CIIL PROGRAM SYNTAX

3.12.2 CHANNEL DESIGNATORS

The channel designator consists of a colon (:) followed by the syntax CH and a single-digit or two-digit channel number. The general form for the channel designator is CHnn and may be any of the following;

:CH00 Designates all outputs.
:CH01 Designates Phase A.
:CH02 Designates Phase B.
:CH03 Designates Phase C.

Channel designators and their applicable noun modifiers are listed in Table 3-13.

3.12.3 OP-CODES

Each of the OP-codes listed is described in following paragraphs.

3.12.3.1 FNC

All set-up strings must begin with OP-code FNC followed by the noun ACS, and the channel designator :CHnn (e.g., FNC ACS :CH03).

3.12.3.2 SET

The SET (set-up) OP-code must be sent when a characteristic included in the output string is to be programmed. The noun modifiers that may follow the SET OP-code are VOLT, FREQ, SYNI, CURL, TRSC and PANG. A SET OP-code is always followed by a noun modifier. A SET string has the following string elements:

FNC ACS :CHnn SET<NOUN-MOD><NUMERIC> <CR> <LF>

An example of a setup string where the phase A output is set to 115.0 volts as follows:

FNC ACS :CH01 SET VOLT 115.0 <CR><LF>

Note that all strings end with ASCII <CR><LF>. The 1503L is configured to recognize this series of ASCII characters as indicating end-of-string (EOS).

TABLE 3-12

CHANNEL DESIGNATORS AND NOUN MODIFIERS

CHANNEL DESIGNATOR	MODIFIER	FUNCTION
:CH00	VOLT	Simultaneously set amplitude for Phase A, Phase B and Phase C
:CH01	VOLT	Set Phase A Amplitude
:CH02	VOLT	Set Phase B Amplitude
:CHO3	VOLT	Set Phase C Amplitude
:CH00	FREQ	Set Frequency
:CH01	FREQ	Set Frequency
:CH02	FREQ	Set Frequency
:CH03	FREQ	Set Frequency
:CH00	PANG	Syntax error with :CH00
:CH01	PANG	Set Phase A phase angle
:CH02	PANG	Set Phase B phase angle
:CH03	PANG	Set Phase C phase angle
:CH00	CURL	Simultaneously set Phase A, Phase B and Phase C current limit.
:CH01	CURL	Set Phase A current limit
:CH02	CURL	Set Phase B current limit
:CH03	CURL	Set Phase C current limit
:CH00	SYNI	Set sync to external signal
:CH00	POWR	Send power measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	POWR	Send power measurement data for Phase A to Bus controller
:CH02	POWR	Send power measurement data for Phase B to Bus Controller
:CHO3	POWR	Send power measurement data for Phase C to Bus Controller
:CH00	APOW	Send apparent power measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	APOW	Send apparent power measurement data for Phase A to Bus Controller
:CH02	APOW	Send apparent powr measurement data for Phase B to Bus controller
:CH03	APOW	Send apparent power measurement data for Phase C to Bus Controller
:CH00	CURR	Send output current measurement data for Phase A, Phase B and Phase C to Bus Controller
:CH01	CURR	Send output current measurement data for Phase A to Bus Controller
:CH02	CURR	Send output current measurement data for Phase B to Bus Controller
:CH03	CURR	Send output current measurement data for Phase C to Bus Controller

3.12.3.3 SRX AND SRN OP-CODES

The SRX (set maximum) OP-code sets the maximum value of the programmable noun modifiers VOLT, FREQ, PANG and CURL. It is always accompanied by a noun modifier. An example of setting the maximum output amplitude of all phases to 135 volts and the output to 115 volts follows:

```
FNC ACS :CH00 SRX VOLT 135 SET VOLT 115.0 <CR> <LF>
```

The SRN OP-code sets the minimum value. For example, to set the minimum value of the output amplitude to 5.0 volts and the output to 20 volts, the following string is transmitted:

```
FNC ACS :CH00 SRN VOLT 5 SET VOLT 20 <CR> <LF>
```

3.12.3.4 OPN and CLS

The CLS (Close) OP-code closes the relay between the amplifier outputs and the output connector. The CLS Op-code must be followed by a valid channel designator. (:CH00, :CH01, :CH02 or :CH03), but all channels close simultaneously for any valid designator. A programmed amplitude will not be generated at the output of the 1503L until the relays have been closed.

```
CLS :CH00 <CR> <LF>   Closes relay
```

If an output voltage been programmed prior to the CLS OP-code, the output will appear after CLS has been sent. If the power source has the MT option, do not program a voltage greater than 30 volts without closing the output relays or the confidence loads in the power source may be damaged.

The OPN (open) OP-code opens the relay at the power source output. Prior to opening the relay, the output of the 1503L is reduced to zero.

```
OPN :CH00 <CR> <LF>   Opens relay
```

3.12.3.5 RST

The RST (reset) OP-code resets the 1503L to its default values as follows:

Output Amplitude	5.0 Volts
Frequency	Selected default frequency
Phase A Phase Angle	0 Degrees*
Phase B Phase Angle	240 Degrees
Phase C Phase Angle	120 Degrees
Sync	Internal
Current Limits	Maximum current of power system
Power Source Relays	Open

*Relative to External Sync.

In addition, all non-catastrophic error messages (SYNTAX and RANGE errors) are cleared. All other error messages are not affected.

OP-code RST must be followed by ACS and any one of the valid channel designators :CH00 through :CH03 (e.g., RST ACS :CH00 <CR> <LF>).

3.12.3.6 CNF and IST

The CNF (confidence) OP-code instructs the 1503L to perform a confidence test of the entire power system. The OP-code stands by itself. The confidence test flow diagram is shown in Figure 3-9. If confidence testing detects a fault, an appropriate message is transmitted to the Bus Controller on receipt of an STA OP-code (see paragraph 3.12.3.9). The output relays of the power source are opened during confidence testing.

During confidence testing, the 1503L generates the following:

Amplitude A, B, C	115 Volts
Frequency	400 Hz
Current Limit	Maximum and 5% of Maximum
B Phase Angle	240 degrees
C Phase Angle	120 degrees

The 1503L compiles a message after the confidence test and the receipt of a STA OP-code. The 1503L responds with the appropriate message as shown in Figure 3-9.

The IST (internal self test) OP-code produces the same response described for CNF.

3.12.3.7 INX

The INX (initialize) OP-code is a request for data from the 1503L. A request for the time required to measure the voltage of all phases consists of the following strings:

```
FNC ACS VOLT :CHnn <CR> <LF>
INX VOLT <CR> <LF>
```

The 1503L then responds with:

```
<SP> 5 <CR> <LF>
```

The 1503L response indicates that 5 seconds will be required to perform the measurement. The measurement time values are stored in read-only memory in the 1503L.

Note that the INX OP-code must be preceded by an FNC OP-code string containing the noun modifier for which INX will request data.

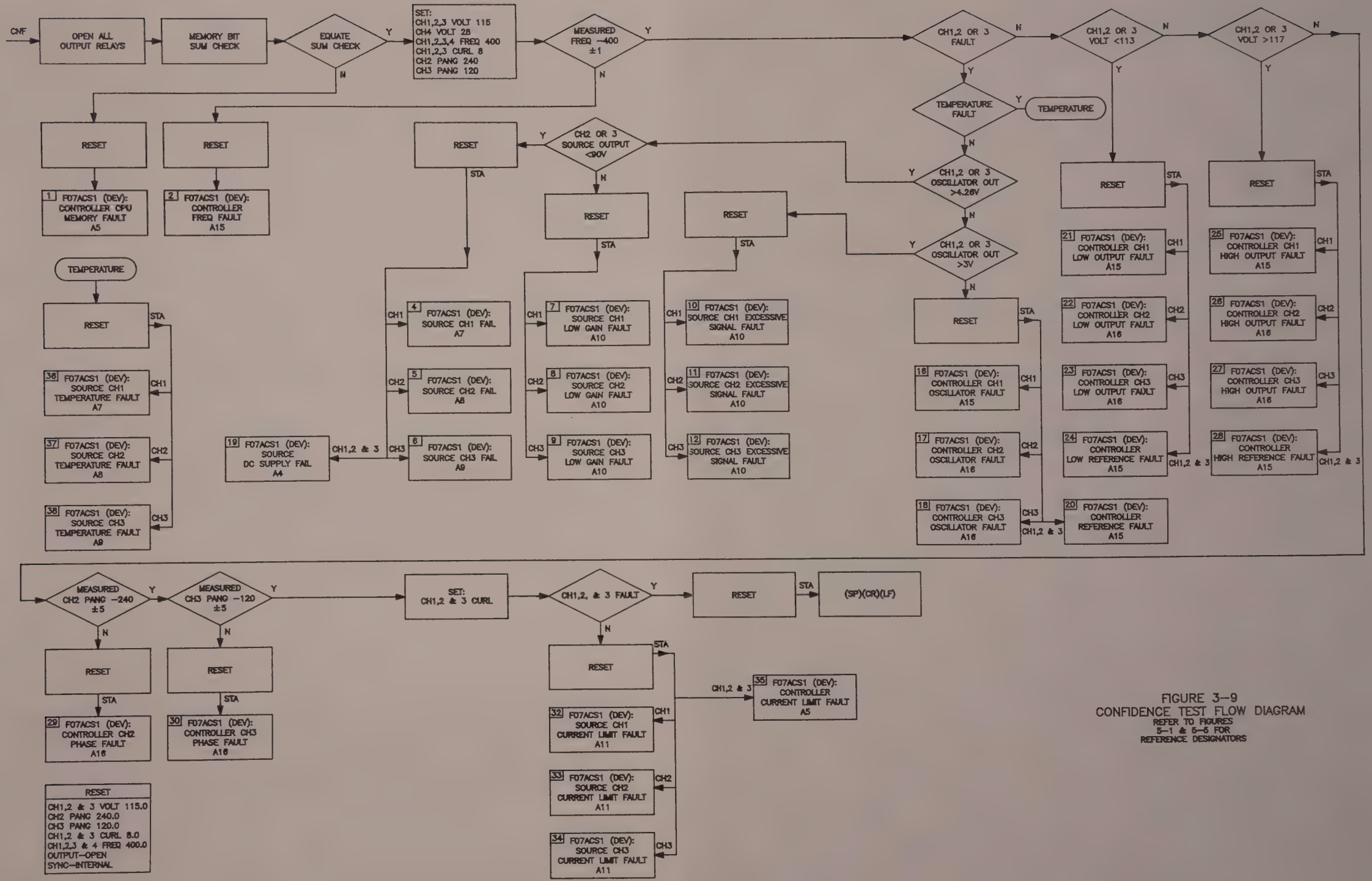

CNF
OPEN ALL OUTPUT RELAYS
MEMORY BIT SUM CHECK
EQUATE SUM CHECK
SET:
CH1,2,3 VOLT 115
CH4 VOLT 28
CH1,2,3,4 FREQ 400
CH1,2,3 CURL 8
CH2 PANG 240
CH3 PANG 120
MEASURED FREQ =400 ±1
CH1,2 OR 3 FAULT
CH1,2 OR 3 VOLT <113
CH1,2 OR 3 VOLT >117
TEMPERATURE FAULT
TEMPERATURE
CH1,2 OR 3 OSCILLATOR OUT >4.26V
CH1,2 OR 3 OSCILLATOR OUT >3V
CH2 OR 3 SOURCE OUTPUT <90V
RESET
STA
1 F07ACS1 (DEV): CONTROLLER CPU MEMORY FAULT A5
2 F07ACS1 (DEV): CONTROLLER FREQ FAULT A15
4 F07ACS1 (DEV): SOURCE CH1 FAIL A7
5 F07ACS1 (DEV): SOURCE CH2 FAIL A8
6 F07ACS1 (DEV): SOURCE CH3 FAIL A9
7 F07ACS1 (DEV): SOURCE CH1 LOW GAIN FAULT A10
8 F07ACS1 (DEV): SOURCE CH2 LOW GAIN FAULT A10
9 F07ACS1 (DEV): SOURCE CH3 LOW GAIN FAULT A10
10 F07ACS1 (DEV): SOURCE CH1 EXCESSIVE SIGNAL FAULT A10
11 F07ACS1 (DEV): SOURCE CH2 EXCESSIVE SIGNAL FAULT A10
12 F07ACS1 (DEV): SOURCE CH3 EXCESSIVE SIGNAL FAULT A10
16 F07ACS1 (DEV): CONTROLLER CH1 OSCILLATOR FAULT A15
17 F07ACS1 (DEV): CONTROLLER CH2 OSCILLATOR FAULT A16
18 F07ACS1 (DEV): CONTROLLER CH3 OSCILLATOR FAULT A16
19 F07ACS1 (DEV): SOURCE DC SUPPLY FAIL A4
20 F07ACS1 (DEV): CONTROLLER REFERENCE FAULT A15
21 F07ACS1 (DEV): CONTROLLER CH1 LOW OUTPUT FAULT A15
22 F07ACS1 (DEV): CONTROLLER CH2 LOW OUTPUT FAULT A16
23 F07ACS1 (DEV): CONTROLLER CH3 LOW OUTPUT FAULT A16
24 F07ACS1 (DEV): CONTROLLER LOW REFERENCE FAULT A15
25 F07ACS1 (DEV): CONTROLLER CH1 HIGH OUTPUT FAULT A15
26 F07ACS1 (DEV): CONTROLLER CH2 HIGH OUTPUT FAULT A16
27 F07ACS1 (DEV): CONTROLLER CH3 HIGH OUTPUT FAULT A16
28 F07ACS1 (DEV): CONTROLLER HIGH REFERENCE FAULT A15
36 F07ACS1 (DEV): SOURCE CH1 TEMPERATURE FAULT A7
37 F07ACS1 (DEV): SOURCE CH2 TEMPERATURE FAULT A8
38 F07ACS1 (DEV): SOURCE CH3 TEMPERATURE FAULT A9
MEASURED CH2 PANG −240 ±5
MEASURED CH3 PANG −120 ±5
SET: CH1,2 & 3 CURL
CH1,2, & 3 FAULT
(SP)(CR)(LF)
29 F07ACS1 (DEV): CONTROLLER CH2 PHASE FAULT A16
30 F07ACS1 (DEV): CONTROLLER CH3 PHASE FAULT A16
32 F07ACS1 (DEV): SOURCE CH1 CURRENT LIMIT FAULT A11
33 F07ACS1 (DEV): SOURCE CH2 CURRENT LIMIT FAULT A11
34 F07ACS1 (DEV): SOURCE CH3 CURRENT LIMIT FAULT A11
35 F07ACS1 (DEV): CONTROLLER CURRENT LIMIT FAULT A5
RESET
CH1,2 & 3 VOLT 115.0
CH2 PANG 240.0
CH3 PANG 120.0
CH1,2 & 3 CURL 8.0
CH1,2,3 & 4 FREQ 400.0
OUTPUT—OPEN
SYNC—INTERNAL

FIGURE 3–9
CONFIDENCE TEST FLOW DIAGRAM
REFER TO FIGURES 5–1 & 5–5 FOR REFERENCE DESIGNATORS

3.12.3.8 FTH

The FTH (fetch) OP-code function fetches data from the 1503L for the parameter indicated by the noun modifier of the previous string. For example, the following FNC string is first sent:

FNC ACS VOLT :CH01 <CR> <LF>

Then the measurement value is requested with:

FTH VOLT <CR> <LF>

Assuming that the output of phase A is 115.5 volts, the 1503L responds with:

<SP> 115.5 <CR> <LF>

The FTH OP-code may be repeated for the same FNC noun modifier.

An INX string may be inserted between the two strings as described in 3.12.3.7, if the time to accomplish the measurement is required.

If the channel indicator in the above example had been :CH00, the 1503L would have responded with the values of all three phases in the order of A, B and C.

3.12.3.9 STA

The STA (status) OP-code instructs the 1503L to transfer its output message to its output buffer. The message is then transmitted to the Bus Controller when the 1503L is addressed to talk. Table 3-4 lists all of the possible status messages generated outside of confidence testing. All confidence testing messages are shown in Figure 3-9.

If the power source is operating correctly and the following OP-code is sent:

STA <CR> <LF>

The 1503L responds with:

<SP> <CR> <LF>

3.12.3.10 GAL

The GAL (go to alternate language) OP-code instructs the 1503L to discontinue use of the CIIL language and start accepting commands in the Abbreviated Plain English (APE) language. While operating in the APE language mode, sending ASCII characters CIIL will return operation to the CIIL language. When power is removed and then restored, the 1503L reverts to the native language.

TABLE 3-13

NON-CNF STATUS MESSAGES

CONDITION	DEVICE RESPONSE
Loaded output Fault	F07ACS01 <SP> (DEV): <SP>OUTPUT CH01/02/03 VOLT FAULT <CR><LF>
Source Temperature Fault	F07ACS01 <SP> (DEV): <SP> SOURCE CH01/02/03 TEMPERATURE <CR><LF>
Program out of range for VOLT, FREQ, PANG or CURL	F07ACS01 <SP> (MOD): <SP> VOLT/FREQ/PANG/CURL RANGE ERROR <CR> <LF>
Unrecognizable OP-code or missing OP-code	F07ACS01 <SP> (MOD): <SP>SYNTAX ERROR <CR><LF>
Good Status	<SP><CR><LF>

3.12.4 NOUN MODIFIERS

Noun modifiers are a CIIL mnemonic indicating the characteristic of the signal to be described.

3.12.4.1 VOLT

The VOLT (voltage) noun modifier may be contained in a string as an instruction to the 1503L with SET, SRX or SRN. Depending on the OP-code, an output voltage (or voltages) may be programmed or set as an upper or lower limit in 0.1-volt increments up to the range limit. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the amplitude to be programmed. For example, to set the output voltage of all three phases to 110 volts, the following string is transmitted:

```
FNC ACS :CH00 SET VOLT 110 <CR> <LF>
```

The noun modifier may also be used in a string that uses the sensor (measurement) capability of the 1503L. An example of requesting the measurement of power source phase A output voltage follows. Note that the noun modifier precedes the channel indicator.

```
FNC ACS  VOLT :CH01 <CR> <LF>
FTH VOLT <CR> <LF>
```

When the output voltage of phase A is 110.0 the 1503L responds with:

```
<SP> 110.0 <CR> <LF>
```

3.12.4.2 FREQ

The FREQ (frequency) noun modifier may be contained in a string as an instruction to the 1503L with SET, SRX or SRN. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. Any one of the four channel indicators may be used in the string. The number which follows the modifier in the string determines the frequency to be programmed. For example, to program all phases to 440 Hertz, the following string is transmitted:

```
FNC ACS :CH00 SET FREQ 440 <CR><LF>
```

The FREQ modifier may also be used to instruct the 1503L to measure the output frequency as follows. Note that the noun modifier precedes the channel indicator:

```
FNC ACS FREQ :CH00 <CR><LF>
```

Followed by string:

```
FTH FREQ <CR> <LF>
```

The response from the 1503L when the frequency is 380.0 Hz is then:

```
<SP> 380.0 <CR> <LF>
```

3.12.4.3 PANG

The PANG (phase angle) noun modifier may be contained in a string as an instruction to the 1503L with SET, SRX or SRN. Depending on the OP-code, an output phase angle (or phase angles) may be programmed or the upper or lower limit set in one-tenth degree increments. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the phase angle to be programmed.

```
FNC ACS :CH02 SET PANG90 <CR> <LF>
```

As with the FREQ and VOLT modifiers, the INX OP-code may be used to request time for PANG measurement:

```
FNC ASC PANG :CH02 <CR><LF>
INX PANG :CH01 <CR> <LF>)
```

When addressed to talk, the 1503L responds with the maximum time required to make the measurement in seconds:

```
<SP> 5 <CR> <LF>
```

When operating in the external sync mode, the phase angle of phase A relative to the external sync input may be programmed as follows:

```
FNC ASC :CH01 SET PANG90 SET SYNI <CR><LF>
```

The phase A output will still track the SYNC input, but will be offset by 90 degrees. The phase angles of phases B and C will still be relative to phase A.

3.12.4.4 CURL

The CURL (current limit) noun modifier may be contained in a string as an instruction to the 1503L with SET, SRX or SRN. Depending on the OP-code, an output current limit (or limits) may be programmed or set as to upper or lower limit in or 0.01 ampere increments up to the power source maximum current. The channel indicator which precedes the modifier determines which phase (or phases) will be so set. The number which follows the modifier in the string determines the current limit to be programmed.

```
FNC ACS :CH00 SET CURL 2.5 <CR> <LF>
```

3.12.4.5 SYNI

SET SYNI enables the external SYNC input. The 1503L returns to the internal sync mode in the absence of the SYNI noun modifier from any set-up string. Any channel indicator may be used in the set-up string that includes SYNI. SYNI may be used with PANG to program the phase A phase angle relative to the sync signal. The following string enables the 1503L to track the frequency and phase of the external sync signal:

```
FNC ACS :CH00 SET SYNI <CR> <LF>
```

Note that other noun modifiers may be included in the above string.

While operating in the external synchronize mode, the 1503L tracks the frequency and phase of the external signal. Note that its phase may be offset from the SYNC input (see paragraph 3.12.4.3). The frequency of the external signal is reported with the following set of strings:

```
(L) FNC ACS FREQ :CH00 <CR> <LF>
(L) INX FREQ <CR> <LF>
(T) <SP> "default time-out value reported"<CR><LF>
(L) FTH FREQ <CR><LF>
(T) <SP> "measured value of external sync frequency reported"
    <CR> <LF>
```

In the above, (L) indicates the 1503L is listen addressed and (T) that it is talk addressed. The INX OP-code in the above series of strings may be omitted if the time data is not required.

3.12.4.6 CURR

The CURR (current measurement) noun modifier's single function is to measure current. The strings to initiate the current measurement of Phase B are as follows:

```
FNC ACS CURR :CH02 <CR> <LF>
FTH CURR <CR> <LF>
```

The current of Phase A, B or C can be measured with channel designators :CH01, :CH02 or :CH03, respectively.

3.12.4.7 POWR

Noun modifier POWR (power measurement) is included in a string to instruct the 1503L to measure the power output of the power source. The strings to initiate the power measurement are as follows:

```
FNC ACS POWR :CH01 <CR> <LF>
FTH POWR <CR> <LF>
```

The response from the 1503L is:

```
<SP> 80.5 <CR> <LF>
```

The foregoing assumes an output power on phase A of 80.5 watts. The power of either Phase A, B or C may be measured.

3.12.4.8 APOW

Noun modifier APOW (apparent power measurement) included in a string instructs the 1503L to measure the apparent power output of the power source in volt-amperes (VA). The strings to initiate the measurement are as follows:

```
FNC ACS APOW :CH01 <CR> <LF>
FTH APOW <CR> <LF>
```

The response from the 1503L is:

```
<SP> 65.5 <CR> <LF>
```

The foregoing assumes an apparent output power on phase A of 65.5 VA.

3.12.5 NORMAL CONDITION RESPONSES

All normal condition responses of the 1503L to requests from the bus controller (either status or measurement requests) begin with an ASCII space <SP>. In the following examples of bus controller/1503L exchange, (L) indicates the 1503L is listen addressed and (T) indicates it is talk addressed.

When the 1503L is requested to measure one of the parameters identified by a noun modifier (e.g., VOLT), the following strings are sent and received by the bus controller:

```
(L) FNC ACS VOLT :CH01 <CR> <LF>
(L) INX VOLT <CR> <LF>
(T) <SP> "default time out" <CR> <LF>
(L) FTH VOLT <CR> <LF>
(T) <SP> 115.5 <CR> <LF>
```

When the 1503L receives an STA OP-code after a CNF OP-code, its normal response is an ASCII space <SP>. An example of the strings transmitted and received is:

```
(L) CNF <CR> <LF>
(L) STA <CR> <LF>
(T) <SP> <CR> <LF>
```

The 1503L accepts the STA OP-code after any string which is sent to it. For example:

```
(L) FNC ACS :CH00 SET VOLT115 SRX VOLT 135 SRN VOLT5 <CR><LF>
(L) STA
(T) <SP> <CR> <LF>
```

3.12.6 ABNORMAL CONDITION RESPONSE

When an abnormal condition has been detected by the 1503L, its response to the STA OP-code will begin with an ASCII F. The abnormal condition may be in the power source or specifically in the power source controller. In the examples that follow, (MOD) is an abbreviation for MODULE and refers to the power controller; (DEV) is an abbreviation for DEVICE and refers to the power source excluding the power controller. The response string for an abnormal condition is:

```
F07ACS01 <SP> (DEV): <SP> "message"<CR> <LF>
```

The status contained in "message" may be similar to the following:

```
OUTPUT CH01&02&03 VOLT FAIL
OUTPUT CH01&02&03 TEMPERATURE FAIL
CONTROLLER CH01&02&03 FREQ FAIL
```

Where a & means "and".

When an STA OP-code is transmitted after any string, the complete abnormal response may be similar to:

```
F07ASC01 <SP> (MOD) : <SP>"message"<CR> <LF>
```

The status contained in "message" may be any of the following for non-CNF messages:

```
SYNTAX ERROR
VOLT RANGE ERROR
FREQ RANGE ERROR
CURL RANGE ERROR
PANG RANGE ERROR
```

The response of the 1503L under a short circuit condition is as follows:

```
F07ACS01<SP>(DEV): <SP> OUTPUT CH01&02&03 VOLT FAULT <CR> <LF>
```

A setup string can always be followed by another string with the STA OP-code. In the event of a syntax, range or system error, an error message will be returned to the bus controller when the 1503L is addressed to talk. The value of the last parameter in a setup string is the one displayed on the front panel of the 1503L.

3.12.7 DISCRETE FAULT INTERRUPT

A discrete fault condition is one that would pose a hazard to equipment or personnel. A Discrete Fault Interrupt (DFI) is supplied with the MT power source option. The DFI relay contacts are connected to the BNC connector, J3, on the 1503L rear panel. Under normal operating conditions, the DFI relay contacts are open; when a fault is detected, the contacts close. The user may connect any type of indicator or alarm circuit to the DFI connector provided the applied signal is limited to 0.1 amps and 26 volts.

The conditions which will cause the discrete fault interrupt are listed in Table 3-14.

TABLE 3-14

DISCRETE FAULT INTERRUPT CONDITIONS

FAULT	CONDITION
OVERLOAD OUTPUT	The full rated power capability is exceed on any phase where programmed output voltage is not maintained.
PROGRAMMABLE CURRENT	The load draws more current than the programmed current limit point on any phase.
OVERTEMPERATURE	Excess heatsink temperature in power supply or output amplifier due to high ambient temperature or internal component failure.
CONTROLLER FAILURE	The AC Power Controller has a CPU failure which is monitored by a watch dog timer.
POWER OFF	Power remains off - input breaker off.

3.12.8 PROGRAM EXAMPLES

Table 3-15 lists some typical CIIL strings. Each one illustrates the versatility in programming which is a feature of the 1503L. The strings listed transmit the information with the fewest possible characters. Decimal points need not be included when followed by zeros. Spaces may not be included anywhere in the string.

TABLE 3-15

SAMPLE PROGRAMMING STRINGS

PROGRAM	STRING
All three phase to 115 volts and current limit to 2 amperes and enable external sync	FNC ACS :CH00 SET CURL2 SET FREQ400 SET VOLT 115 SET SYNI <CR><LF>
Phase B to 100 volts and current limit to 2 amps	FNC ACS :CH02 SET CURL.2E1 SET FREQ4E2 SET VOLT100 <CR><LF>
To power-up state open relay	RST ACS :CH00 <CR><LF>
Phase B to 90 degrees	FNC ACS :CH02 SET PANG90 <CR><LF>
Freq. to 65.23 Hz	FNC ACS :CH00 SET FREQ65.23 <CR><LF>
All three phases to 2.5 amps average current limit	FNC ACS :CH00 SET CURL2.5 <CR><LF>
Phase C current limit to 2 amps average	FNC ACS :CH03 SET CURL2 <CR><LF>
Confidence test	CNF <CRL><LF>
For status msg	STA <CR><LF>
Output relay closed	CLS :CH00 <CR><LF>
To measure output voltage only of Phase A	FNC ACS VOLT :CH01 <CR><LF>
Output relay opened	OPN :CH00 <CR><LF>
To measure Freq.	FNC ACS FREQ :CH00 <CR><LF> FTH FREQ <CR><LF>
To measure output voltage of all phases	FNC ACS VOLT <CR><LF>
Query time of measure-ment of voltage	FNC ACS VOLT <CR1><LF> INX VOLT <CR><LF>

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 4

CALIBRATION PROCEDURE

4.1 GENERAL

The calibration is divided into two categories; a periodic and a nonperiodic calibration. The periodic calibration should be performed at a 1 year interval. The nonperiodic calibration should only be performed if the periodic calibration cannot be performed or if an adjustable subassembly is replaced.

The following is a listing of paragraphs that may be performed to fix an indicated problem.

PARAGRAPH	TITLE
4.3.1	OUTPUT VOLTAGE CALIBRATION
	This is a periodic calibration of the output voltage.
4.3.2	VOLTAGE MEASUREMENT CALIBRATION
	This is a periodic calibration of the voltage measurement function.
4.3.3	CURRENT MEASUREMENT CALIBRATION
	This is a periodic calibration of the current measurement function.
4.3.4	POWER MEASUREMENT CALIBRATION
	This is a calibration of the power measurement function.
4.3.5	REMOTE MEASUREMENT CALIBRATION
4.4.1	OUTPUT FREQUENCY CALIBRATION
	This is a nonperiodic calibration of the output frequency.
4.4.2	CURRENT TRANSFORMER ADJUSTMENT
	These are nonperiodic adjustments. The adjustments are required if it is impossible to perform the current or power measurement calibration (Ref. Paragraph 4.3.3 and/or 4.3.4).

4.4.3 CURRENT LIMIT CALIBRATION

This is a nonperiodic calibration. The calibration is required if the available output current is not equal to the programmed current limit value. The available output current may exceed the programmed value by 10%.

4.4.4 OUTPUT PHASE ANGLE CALIBRATION

This is a nonperiodic calibration. The calibration is required if there is an error in the phase B or C output phase angle relative to phase A.

4.4.5 GAIN ADJUSTMENT

This is a nonperiodic adjustment. The adjustments are required if there is an AMP FAULT error message when the power source is operated at full-load at high frequency.

4.2 TEST EQUIPMENT

The following equipment or their equivalents are required to completely test the AC Power System.

TEST EQUIPMENT FOR PERIODIC CALIBRATION

1. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent.

2. 10 Amp Current Transformer: Pearson Model 110

3. Resistive Loads: See LOAD RES value from Table 4-1

ADDITIONAL TEST EQUIPMENT

4. Frequency Counter: Philips PM 6671

5. Phase Angle Meter: Krohn-Hite 6500A

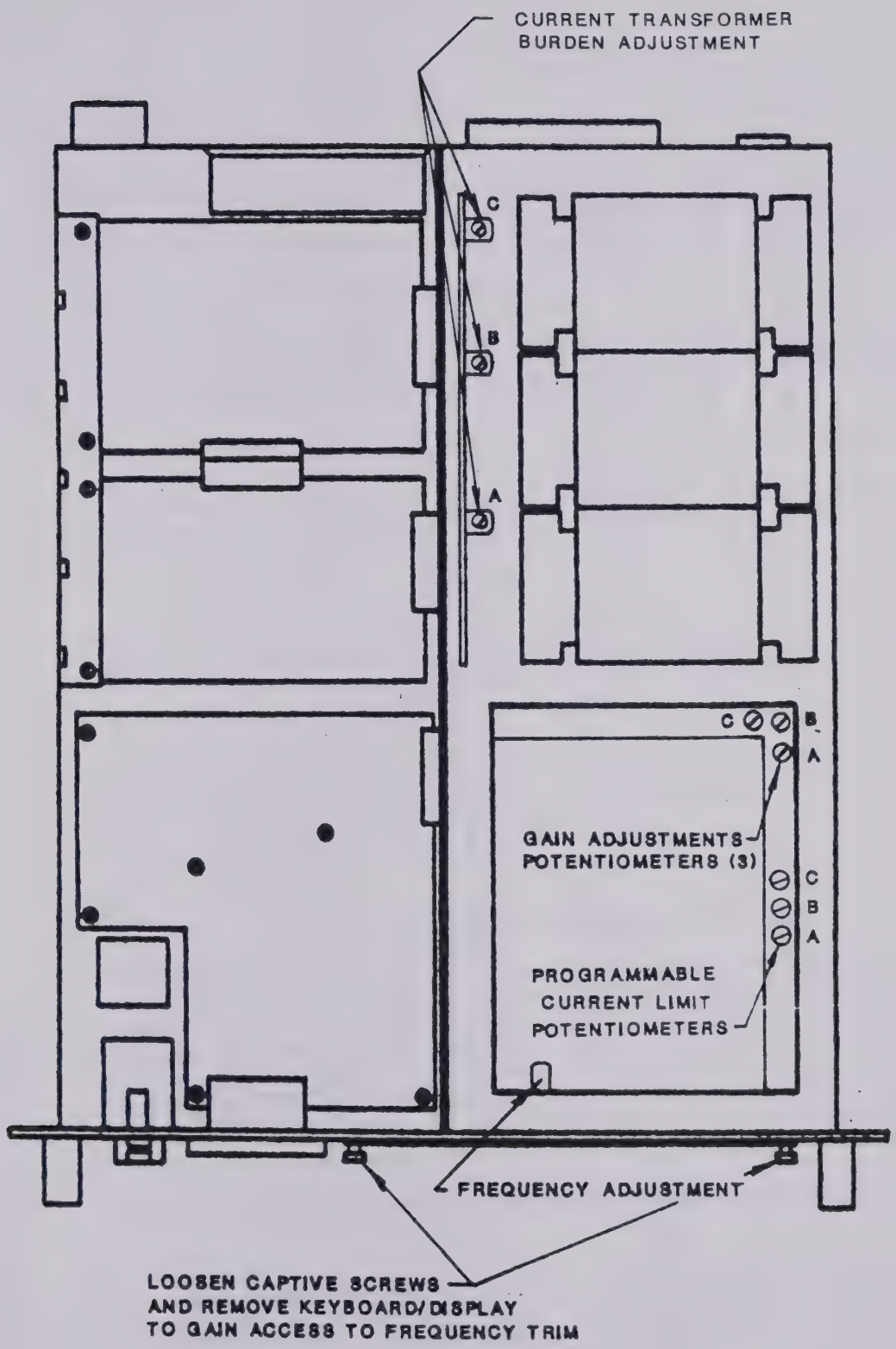
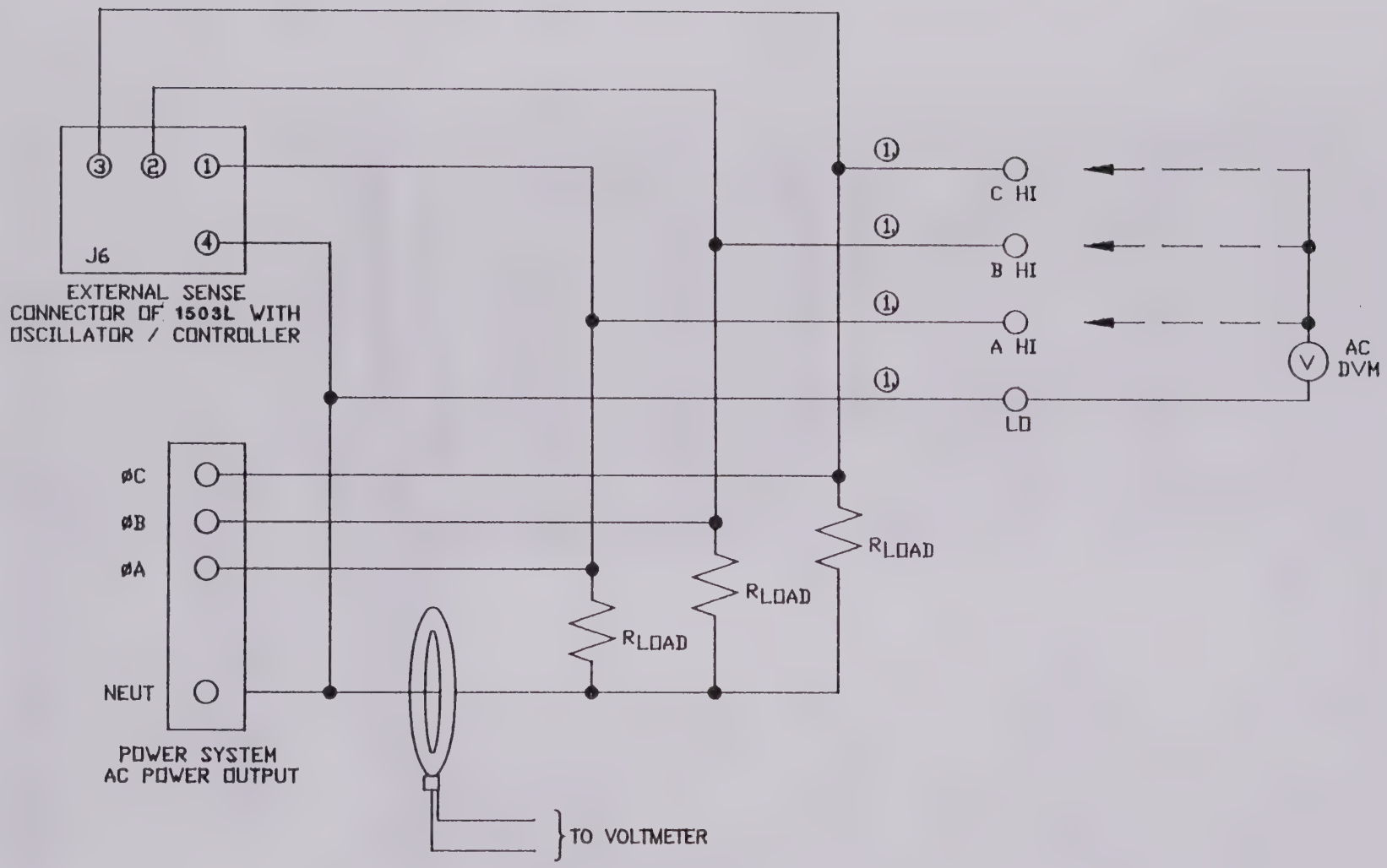


FIGURE 4-1

POWER SOURCE ADJUSTMENTS (TOP COVER REMOVED)



① NOTE: AC DVM MUST BE CONNECTED TO SENSE LINES INSTEAD OF CURRENT CARRYING WIRES

FIGURE 4-2

4.3 PERIODIC CALIBRATION

The following periodic calibration adjustments should be performed on a 1 year interval. The Remote Sense lines at the rear panel connector, J6, must be connected to the output barrierstrip, TB2.

4.3.1 OUTPUT VOLTAGE CALIBRATION

Apply power to the AC Power System and allow at least fifteen minutes for temperature stabilization. Program the output to 60 Hz, 135 volts and perform the following steps:

1. Connect the AC voltmeter to the phase to be calibrated.

2. Depress the MNU key several times until the first menu screen is displayed as illustrated below.

```
 SNC = 01        *CLK = 02
*WVF = 03         RNG = 04
```

   *May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

5. Select the CAL screen with the key sequence: 12 ENT

6. Depress the A, B or C key for the output phase to be calibrated. Verify that the other phases are in the MON mode. The A, B or C keys will switch the respective phase between the MON and PRG mode. If the output voltage is greater than the programmed output, depress and hold the ↓ key until the correct output voltage has been reached. The ↑ key is used if the output is less that the programmed value.

7. Repeat step 6 for other outputs to be calibrated.

4.3.2 VOLTAGE MEASUREMENT CALIBRATION

For calibration of voltage measurement first perform the output voltage calibration and then perform the followings steps:

1. Remove the load from the AC Power System and program 60 Hz and 135.0 volts.

2. Depress the MNU key several times until the Menu screen is displayed as illustrated below:

```
 SNC = 01    *CLK = 02
*WVF = 03     RNG = 04
```

   *May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT.

4. Depress the MNU key several times until the configuration menu screen is displayed.

```
CFG = 16     ALM = 17
FLM = 18     CLM = 19
```

5. Enter the key sequence 13 ENT to access the CAL VLT screen.

6. If all phases of the voltage measurement are to be calibrated to 135.0, enter the key sequence:

   135 PRG ENT

   After about 5 seconds, the volt measurement function will be calibrated for all three phases.

   If only one phase is to be calibrated to 135.0 volts (ex., phase A) enter the key sequence:

   135 A PRG ENT

	VOLTAGE RANGE			
	STANDARD 135/270	LV 67.5/135	HV 156/312	EHV 200/400
LOAD RES	32.7	8.2	43.7	71.9
CURRENT LIMIT				
PROGRAM VALUE	3.3	6.1	3.1	2.3
SET VALUE	3.5	6.5	3.3	2.5

SETUP VALUES/LOAD VALUES

TABLE 4-1

4.3.3 CURRENT MEASUREMENT CALIBRATION

For calibration of current measurement perform the following steps:

1. Program 60 Hz, the low voltage range, the maximum voltage and the maximum Current Limit value.

2. If any calibration screen is already displayed, the Current Calibration screen (CAL CUR) may be displayed by repeatedly depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, press the MNU key several times until the screen shown below is displayed:

```
 SNC = 01  *CLK = 02
*WVF = 03   RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed, as shown below:

```
CFG = 16      ALM = 17
FLM = 18      CLM = 19
```

5. Enter the key sequence: 14 ENT to access the CAL CUR screen.

   Determine the full load resistive value from the LOAD RES value from Table 4-1.

6. Apply the load to the phase A output only. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer.

7. On the keypad enter the key sequence:

   (Measured phase A current. Example 11.05) A PRG ENT

   After about 5 seconds the current measurement function for phase A will be calibrated.

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B current) B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

    (Measured phase C current) C PRG ENT

4.3.4 POWER MEASUREMENT CALIBRATION

For calibration of power measurement perform the following steps:

1. Program 60 Hz, the low voltage range, the maximum output voltage and the maximum Current Limit value.

2. If any calibration screen is already displayed, the Power Calibration screen (CAL PWR) may be displayed by depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, depress the MNU key several times until the screen shown below is displayed:

```
 SNC = 01    *CLK = 02
*WVF = 03     RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as shown below:

```
CFG = 16     ALM = 17
FLM = 18     CLM = 19
```

5. Enter the key sequence 15 ENT to access the CAL PWR screen.

6. Apply the LOAD RES value from Table 4-1 to the phase A output only. Measure the phase A output current with the AC Digital Voltmeter and Current Transformer. Measure the phase A voltage from the phase A sense to neutral sense. Multiply the voltage and current values to determine the power value. (Note: The load must be resistive for the correct power value.)

7. On the keypad enter the key sequence:

   (Measured phase A power)4 A PRG ENT

8. Repeat step 6 for phase B.

9. Repeat step 7 except enter the key sequence:

   (Measured phase B phase)4 B PRG ENT

10. Repeat step 6 for phase C.

11. Repeat step 7 except enter the key sequence:

    (Measured phase C power) C PRG ENT

4.3.5 REMOTE MEASUREMENT CALIBRATION

The measurement function of the AC Power System may be remotely calibrated. The equipment hookup is the same as before except an IEEE-488 Controller must be used to program the AC Power System. The values for the VLT, CUR and PWR strings must be derived from the external AC Digital Voltmeters and Current Transformer.

To calibrate the measured voltage, first program the AC Power System to the maximum voltage on the low voltage range and 60 Hz. Send the following calibration string:

```
CAL VLT (1)     (Desired voltage value for phase (1))
```

To calibrate the measured current send the following string:

```
CAL CUR (1)     (Desired current value for phase (1))
```

To calibrate the measured power value send the following string:

```
CAL PWR (1)     (Desired power value for phase (1))
```

NOTE: (1) May include an A, B or C extension.

4.3.6 REMOTE OUTPUT VOLTAGE CALIBRATION

The ASCII # symbol can be used with a remote calibration to greatly reduce the calibration time. The ASCII # is used in place of a calibration coefficient to begin the CAL ramp to start at the existing CAL coefficient and ramp up or down for a VAL argument of 255 or 0 respectively.

The following string will cause the CAL coefficient to ramp down with a delay of .2 seconds per step:

```
CAL # DLY.2 VAL0
```

Figure 4-3 is a Flow Diagram for the Remote Calibration program that follows. The program was written in HP Basic for an HP Series 80 computer.

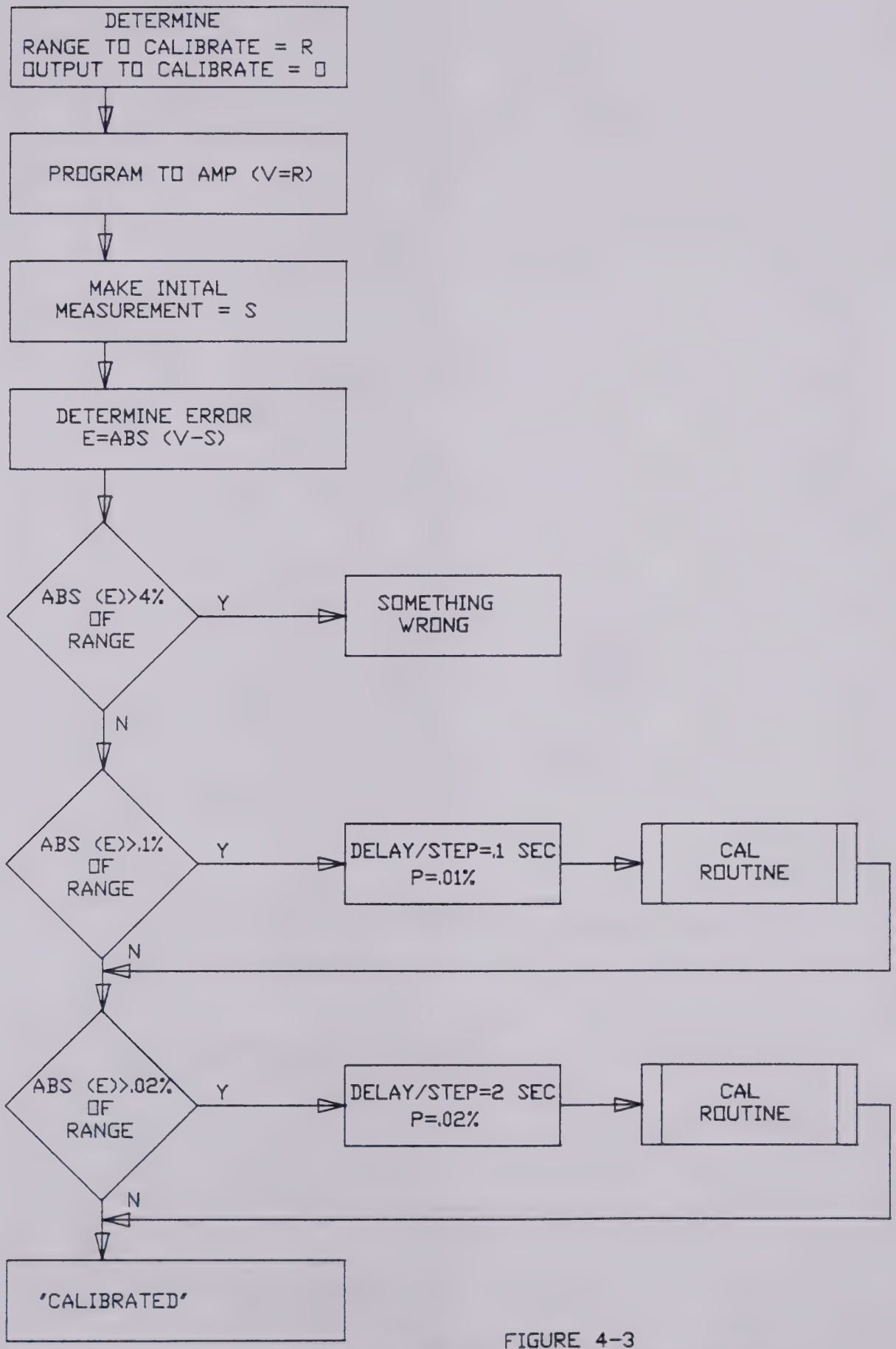


FIGURE 4-3
REMOTE CALIBRATION FLOW DIAGRAM

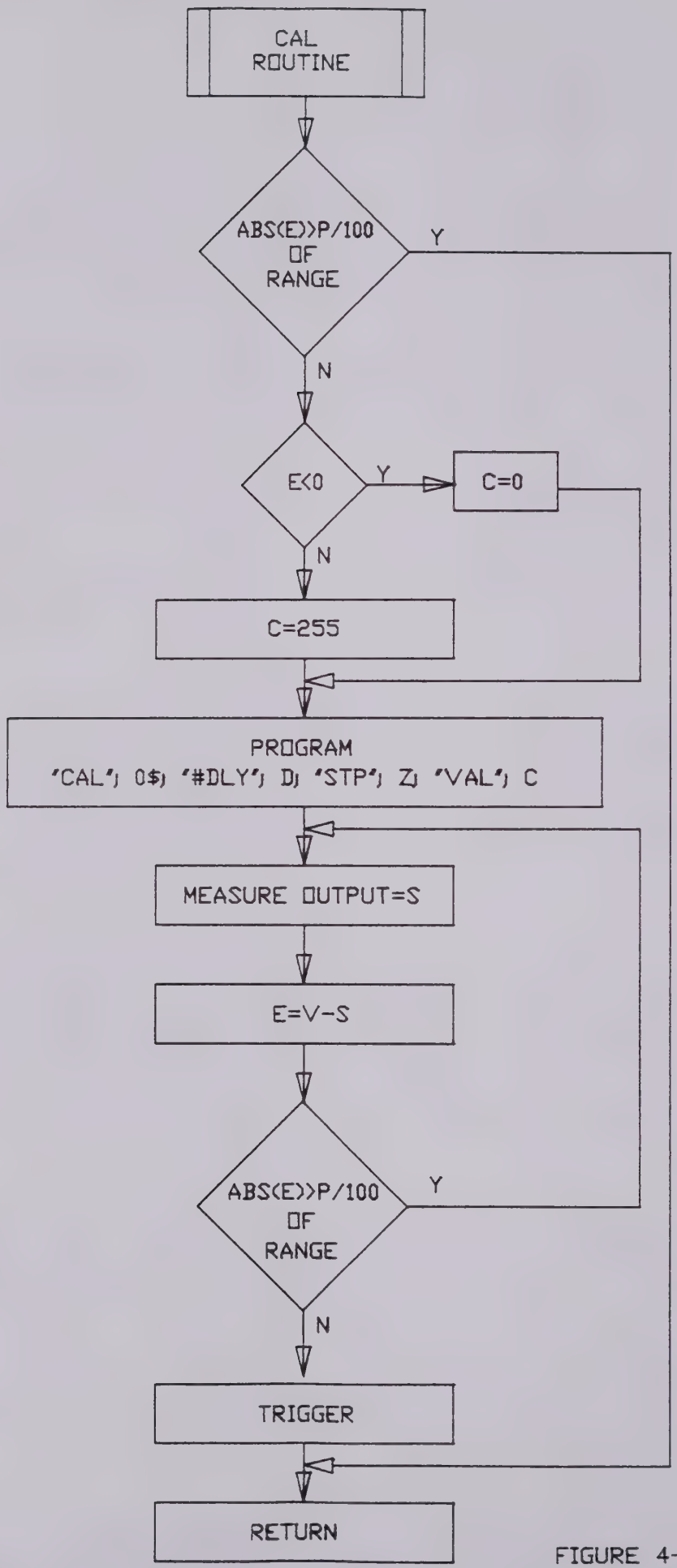


FIGURE 4-3 (CONTINUED)

```
10  ! CAL
20  SET TIMEOUT 7;5000 ! SET BUS TIMEOUT TO 5SEC
30  ! CLEAR 7! SEND DEVICE CLEAR
40  CLEAR
50  ABORTIO 7
60  R=135
70  O$="A"
80  DISP "THE AC POWER SYSTEM ADDRESS MUST BE 1 AND "
90  DISP "THE 8506A AC DVM ADDRESS MUST BE 4."
100 DISP "PRESS K1 TO CONTINUE"
110 ON KEY# 1 GOTO 140
120 GOTO 120
130 OFF KEY#
140 DISP "WHAT VOLTAGE RANGE TO CAL 135 OR 270.DEFAULT IS ";R
150 INPUT C$
160 IF C$ <> "" THEN R=VAL (C$)
170 CLEAR
180 IF R=135 THEN DISP "WHAT CAL. VOLTAGE FROM 60 TO 135? THE
    DEFAULT IS 135"
190 IF R=270 THEN DISP "WHAT CAL. VOLTAGE FROM 120 TO 270? THE
    DEFAULT IS 270."
200 INPUT V$
210 IF V$ <> "" THEN V=VAL (V$) ELSE V=R
212 ON TIMEOUT 7 GOTO 2000
214 IF V>125 THEN OUTPUT 704 ;"VAR7,"
216 IF V>40 AND V<= 125 THEN OUTPUT 704 ;"VAR6,"
218 IF V<= 40 THEN OUTPUT 704 ;"VAR5,"
220 DISP "WHICH OUTPUT TO CAL(DEFAULT IS ";O$;")"
230 INPUT P$
240 IF P$ <> "" THEN O$=P$
250 CLEAR
260 DISP "CONNECT THE 8506A AC DVM TO OUTPUT ";O$;"."
270 DISP "PRESS K1 TO CAL."
280 ON KEY# 1 GOTO 300
290 GOTO 290
300 OFF KEY#
310 GOSUB 1000
320 ! OUTPUT CALIBRATED TO WITHIN .02%
330 DISP "OUTPUT ";O$;" CALIBRATED. CAL ANOTHER OUTPUT(Y/N)"
340 INPUT A$
350 IF POS (A$,"Y")=1 THEN GOTO 220
360 LOCAL 7
370 END
500 ! CAL SUBROUTINE
510 ! DETERMINE IF OUTPUT IS WITHIN P% OF R
512 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
515 GOSUB 800
520 IF ABS (E)<P/100*R THEN GOTO 600
530 ! DETERMINE DIRECTION OF CAL COEFF. RAMP
540 IF E<0 THEN C=0 ELSE C=255
545 ON TIMEOUT 7 GOTO 3000
550 OUTPUT 701 ; "CAL AMP";O$;"#DLY";D;"STP";Z;"VAL";C
560 X=255
562 GOSUB 800
564 IF ABS (E)>ABS (X)+.005 THEN GOTO 590
```

```
566 IF ABS (E)<P/100*R THEN GOTO 590
568 WAIT D*1000
570 X=E
580 GOTO 562
590 TRIGGER 701 ! STOP CAL RAMP WITH DEVICE TRIGGER
600 RETURN
800 ! MEASURE ROUTINE
810 OUTPUT 704 ; "?"
820 ENTER 704 ; 6
830 E=V-S
840 RETURN
1000 ! GEN CAL
1010 ! PROGRAM TO SELECTED RANGE AND AMPLITUDE
1020 OUTPUT 701 ;"FRQ400RNG";R;"AMP";V
1030 WAIT 2000
1040 ON TIMEOUT 7 GOTO 2000
1042 WAIT 2000
1050 GOSUB 800
1070 UF ABS (E)>,04*R THEN GOTO 3000 ! NOT AT EXPECTED OUTPUT
1080 D=1 @ P=.1 @ Z=10 ! DLY=.1SEC FOR CAL TO APPROX. .1%
1090 GOSUB 500
1100 D=1 @ P=.02 @ Z=1 ! DLY=1SEC FOR CAL TO .02%
1110 GOSUB 500
1120 RETURN
2000 DISP "DVM IS INACTIVE. INSURE ADDRESS IS 4."
2010 GOTO 360
3000 DISP "CHECK THAT THE ADDRESS IS 1."
3010 DISP "THE MEASURED OUTPUT IS ",S
3020 GOTO 360
```

4.4 NONPERIODIC CALIBRATION

If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power System will have to be removed. A nonperiodic calibration will only be required if a related assembly is replaced or if the performance is out of specification.

4.4.1 OUTPUT FREQUENCY CALIBRATION

Connect the Frequency Counter to the phase A output. Program the output to 135.0 volts and 400.0 Hz. Engage the low-pass filter on the Frequency Counter to obtain the output frequency.

If the Frequency Counter does not indicate 400.000 ±0.004 Hz, adjust C43 for the correct frequency. Refer to Figure 4-1.

4.4.2 CURRENT TRANSFORMER BURDEN ADJUSTMENT

A current transformer is in series with each of the three amplifiers to sense output current for measurement and protection. The output current of each sense transformer is converted to a voltage by an adjustable burden resistor. Use the following procedure to adjust the burden resistor of an amplifier's current sense transformer. See Figure 4-1 for the location of the burden potentiometers.

1. Wire the output of the phase to be adjusted through a precision current transformer. Monitor the output of the current transformer with a DVM set at 2 volts AC full scale.

2. At the rear panel system interface connector, monitor the current transformer output voltage of the amplifier to be adjusted with a DVM set at 2 volts AC full scale.

J7-36	CT A
J7-18	CT B
J7-35	CT C
J7-5	CT COM (common)

3. Switch the power source on. Program the output to the maximum voltage on the low voltage range and 400 Hz.

4. Apply full load (see LOAD RES value from Table 4-1) to the output of the phase to be adjusted.

5. Allow 30 seconds for the load to stabilize. Adjust the burden potentiometer so that the DVM monitoring the power source current transformer matches the DVM on the precision current transformer within ±0.0004V rms.

4.4.3 CURRENT LIMIT CALIBRATION

1. Select the Current Limit (CRL) screen (Screen 8) and program the Current Limit PROGRAM VALUE from Table 4-1.

2. Monitor the power system phase A output current with the external current transformer and AC DVM. Connect an oscilloscope to the output.

3. Program the low voltage range and the voltage to 80% of range. Program the frequency to 60 Hz.

4. Apply the LOAD RES value from Table 4-1 to the power system phase A output only.

5. Increase the output voltage slowly until the external AC current transformer indicates SET VALUE from Table 4-1. Slowly turn R55 on the Current Limit Assembly (A11) until the output OVERLOAD indicator starts to illuminate.

6. Slowly readjust R55 in the opposite direction just to a point that the OVERLOAD extinguishes.

7. Remove the load for phase A and repeat steps 2) through 6) for phase B and C. Adjust A11-R62 for Phase B and A11-R75 for Phase C.

4.4.4 OUTPUT PHASE ANGLE CALIBRATION

The phase calibration values for phases B and C are entered on the Phase Offset (POF) screen.

To calibrate the output phase angle, connect either a Phase Meter or an oscilloscope between the phase to be calibrated and the phase A output. Program the phase B or C value to be calibrated from the Phase screen (PHZ). If an oscilloscope is used the calibration is best performed with a programmed angle of 0 degrees.

To calibrate the output phase angle, program 120.0 volts and 60 Hz.

To access the POF screen perform the following key sequences:

1. Access the Phase screen (PHZ).

2. Depress the MNU key several times until the following screen is displayed:

```
SNC = 01        CLK = 02
WVF = 03        RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the Configuration menu screen is displayed:

CFG = 16	ALM = 17
FLM = 18	CLM = 19

5. To display the POF screen enter the key sequence: 20 ENT

If an oscilloscope is used and the respective phase is programmed to 0 degrees and 200 Hz, a 3 degree error is represented by 41 microseconds of the 0 volt point of the two signals.

The POF values may be either a positive or negative value. A negative value is entered by depressing the period (.) key two times after the numerical value is entered before the PRG key is depressed.

4.4.5 GAIN ADJUSTMENT

A gain adjustment potentiometer is provided for each of the three amplifiers in the power source. For their location see Figure 4-1. use the following procedures to adjust the gain of an amplifier with programmable power controller.

1. Remove all loads from the power source. Disconnect the External Sense connector, J6. Switch the power source on.

2. Monitor the output voltage of the amplifier to be adjusted.

3. Program the output to 100V rms, 400 Hz. Hold the enter key down on the programmable power controller to disable fault detection and adjust the associated potentiometer until the output voltage is 115.00 ±0.5V rms.

4. Reconnect the External Sense connector, J6.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

An explanation of the circuits within the 1503L is given in this section. Refer to Figure 5-1 for a block diagram of the power source.

5.2 OVERALL DESCRIPTION

Input power at the rear panel is routed through the circuit breaker to the high current rectifier, CR1, and the DC Supply assembly, A4. The various DC supply outputs then go to the Power Mother Board, A3, to be directed to other circuits in the 1503L.

The Power Controller assembly generates the oscillator waveforms and power source control and measurement signals. The Power Controller assembly is connected to the rest of the power source through the Control Mother Board, A10.

The amplifiers, A7, A8, A9, take their DC Supply and Power Controller inputs from the Power Mother board and produce the 500 VA outputs to the Range Relay board, A6.

The Range Relay board directs the amplifier outputs to Output Transformers T1, T2, and T3. The transformer outputs are then connected back to the Range Relay board to configure the correct output voltage range. The final power source outputs are then taken from the Range Relay board.

The PH DE1 and PH DE2 assemblies are installed if the AX option is included in the 1503L. These two boards generate the ϕD/E outputs using signals and power supplies taken from the power mother board, A3. The ϕD/E outputs are routed through the Range Relay board, A6 and then to the rear panel output terminal block, TB-2.

The individual assemblies are explained in more detail in the following paragraphs.

5.3 DC SUPPLY

The DC Supply board, A4, provides the high-voltage main supply and several low voltage power supplies. Figure 5-2 is a simplified schematic of the DC supply. The input circuit breaker and high power rectifier are shown in the diagram for clarity but are not part of the DC Supply board.

5.3.1 HIGH VOLTAGE SUPPLY

The high voltage supply provides a 300 volt, 2000 watt source for the three power amplifiers. The input wiring of this supply is configured according to the input voltage range. A voltage doubler is used for the 115 volt range; a full wave rectifier is used for the 230 volt range.

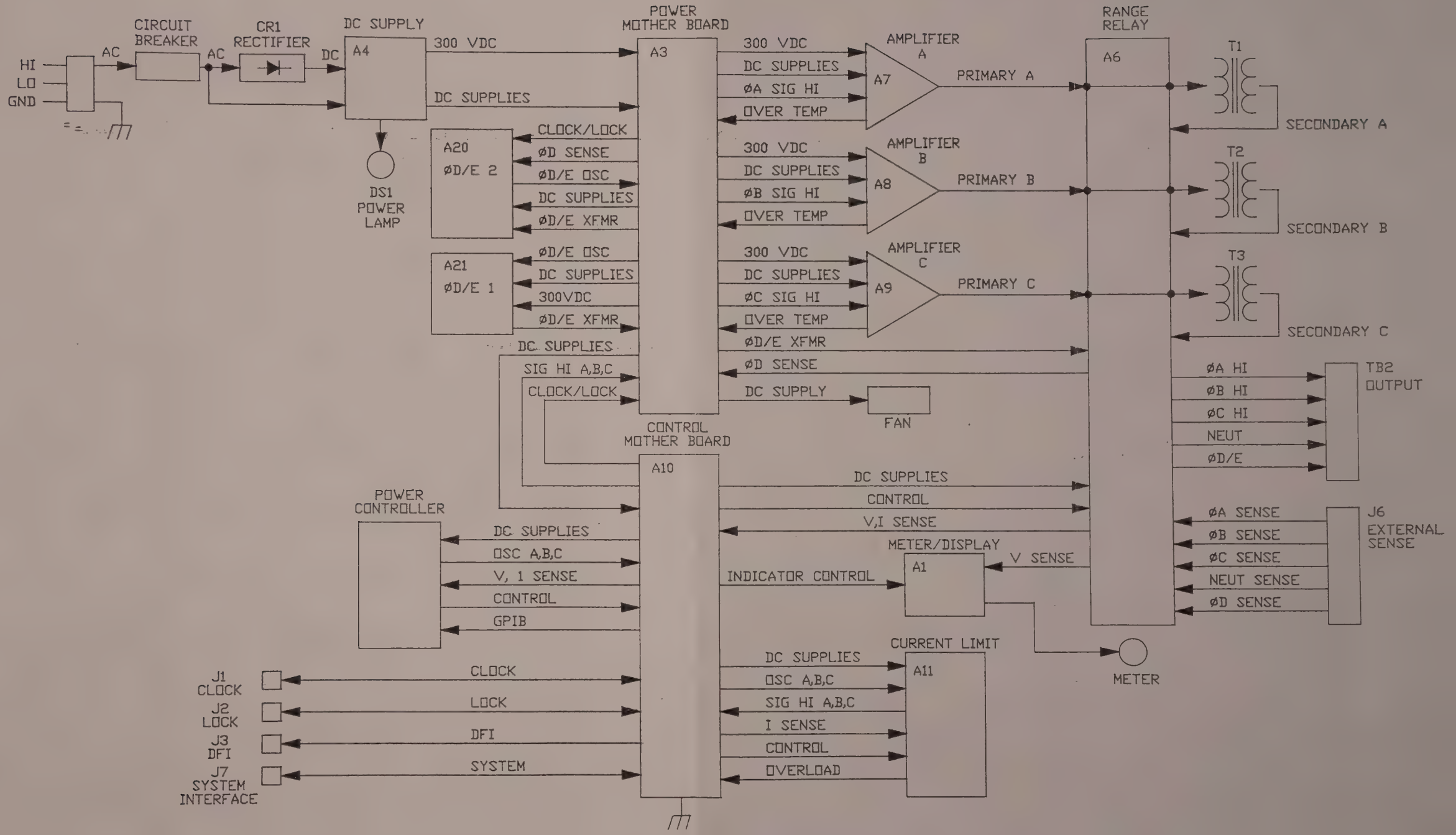


FIGURE 5-1 1503L-3P BLOCK DIAGRAM

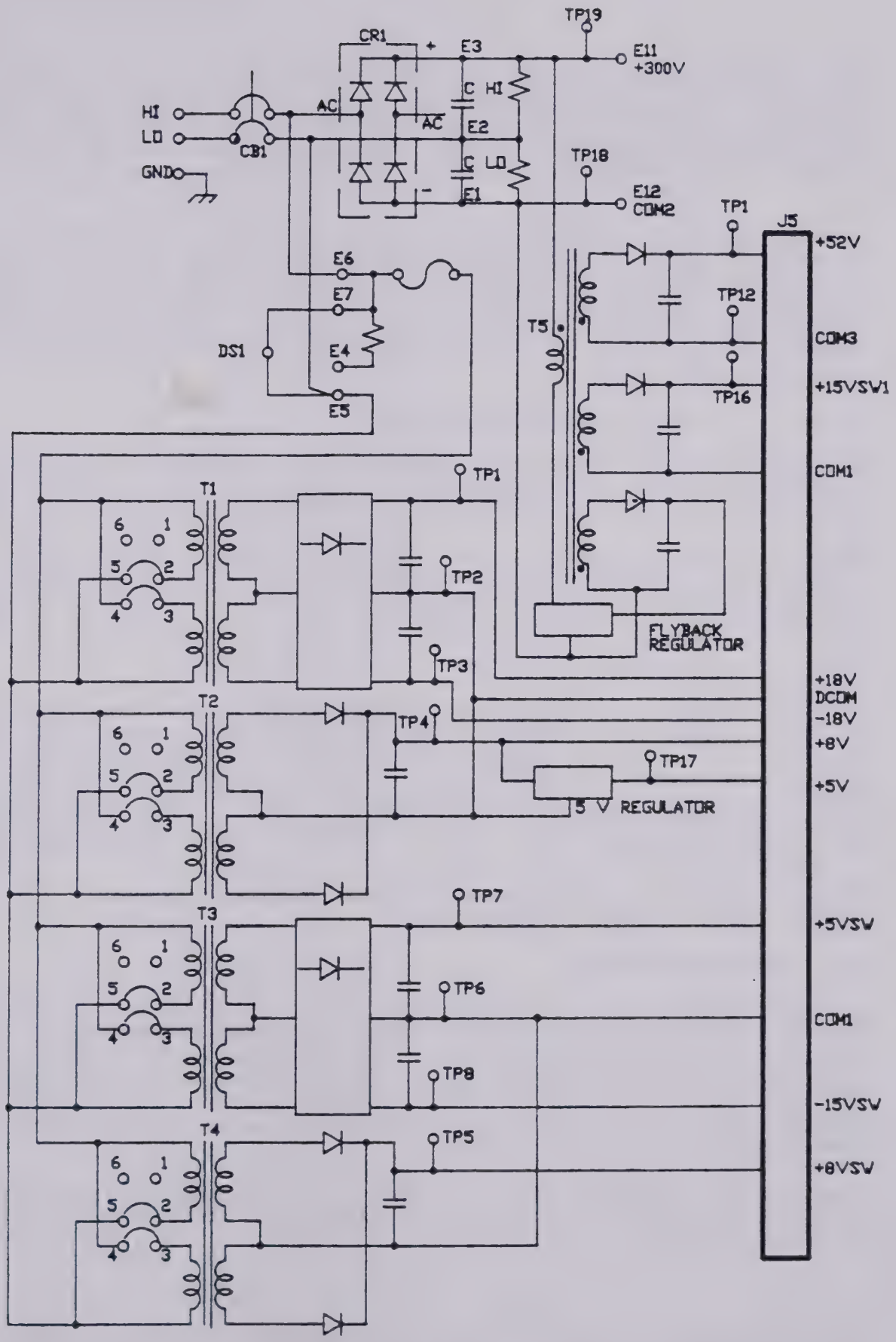


FIGURE 5-2 DC SUPPLY

Figure 5-2 shows the high voltage supply wired for the voltage doubler. Capacitors C-HI and C-LO are charged by alternate half cycles of the input voltage. The output voltage at E11 and E12 is the sum of the voltages on the two capacitances and is approximately double the peak voltage of the input sine wave.

To wire the high voltage supply for the 230 volt input range, the connection between CB-1 and E2 is removed and replaced by a connection between CB-1 and the unused AC input of CR-1. The circuit is a simple off-line rectifier. Capacitors C-HI and C-LO are charged in series by each half cycle of the input voltage. The output voltage at E11 and E12 is approximately the peak voltage of the input sine wave.

5.3.2 FLYBACK REGULATED SUPPLIES

Two of the eight low voltage supplies are provided by a 100 KHz flyback regulator. The regulator switches on to draw energy from the 300 volt main supply and charge the primary inductance of T5.

When the regulator switches off, the energy stored in the primary inductance is transferred to the secondaries. The pulse width of the switching waveform is varied as necessary to maintain the secondaries at +15 VDC and +52 VDC.

5.3.3 LOW VOLTAGE SUPPLIES

Six low voltage supplies are generated by simple transformer/rectifier/capacitor circuits. The inputs to each transformer are wired according to the input voltage range. Figure 5-2 shows the inputs configured for the 115 volt input. The two primaries of each transformer are wired in parallel. For the 230 volt input range, the transformers are reconfigured using jumpers that put the two primaries in series.

These supplies are not regulated. Their output voltages vary with line voltage and load variations.

5.4 POWER CONTROLLER

A block diagram for the Programmable Power Controller is given in Figure 5-3. The Programmable Power Controller generates the oscillator waveforms for each of the three amplifiers, sets the amplitude, frequency, phase angle, and maximum average current of the outputs, senses the output voltage to control amplitude, and measures the voltage, current, frequency, phase angle, and power of the outputs.

The module is made of four printed circuit assemblies that plug into a small mother board. An extender board mates the module to the power source.

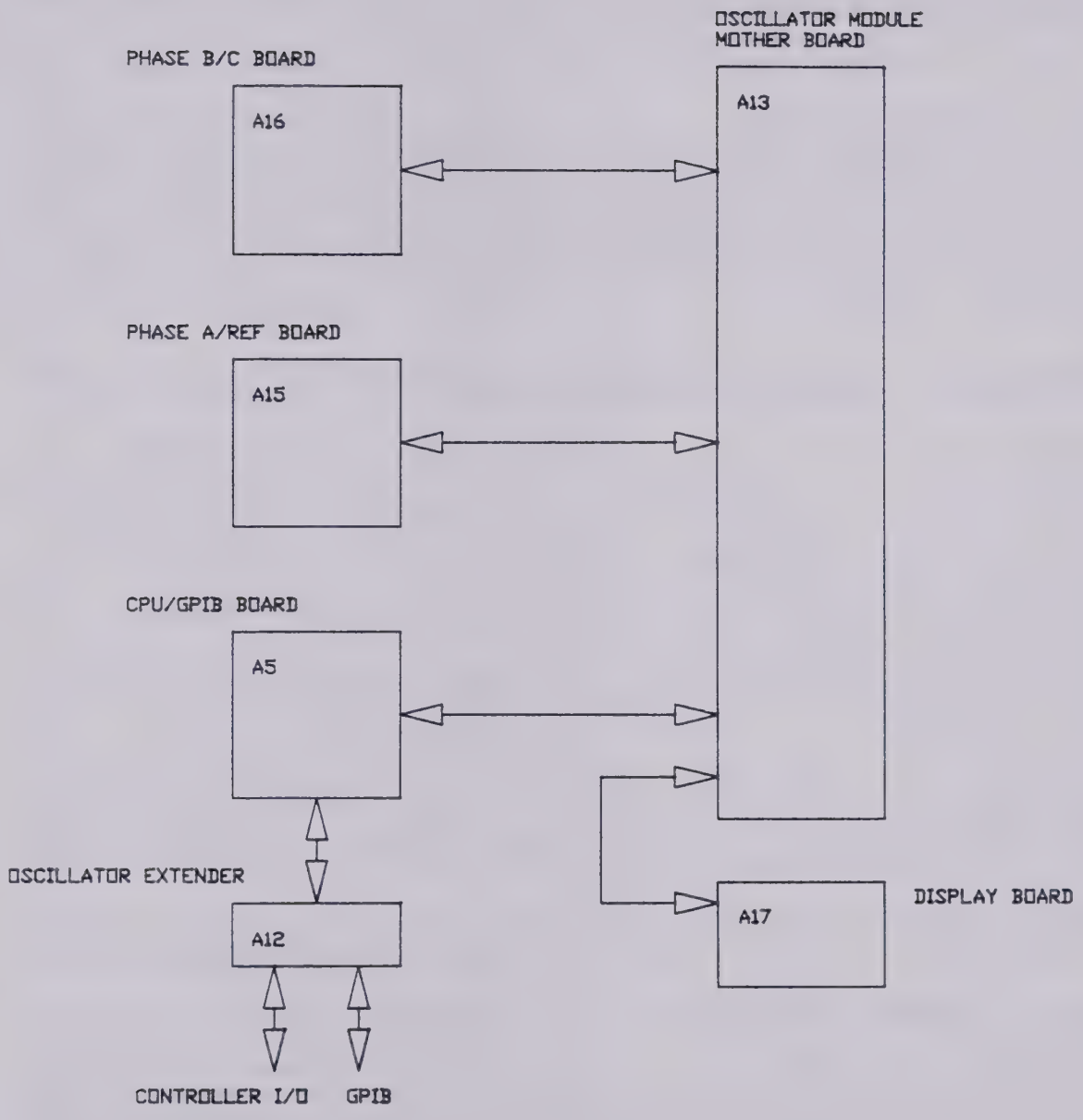


FIGURE 5-3 PROGRAMMABLE POWER CONTROLLER

5.4.1 OSCILLATOR MODULE MOTHER BOARD

The Oscillator Module Mother board, A13, connects the four main assemblies of the module.

5.4.2 CPU/GPIB BOARD

The CPU/GPIB board, A5, provides the control and measurement functions of the module. A microprocessor circuit accepts commands from the GPIB or the front panel keyboard. It sends digital programming information to set the output parameters of the power source. Data from measurement circuits are accepted and reported to the display and GPIB. Measurement calibration coefficients are stored in a memory backed up by a battery. The battery has a 10 year life expectancy.

Measurement circuits on the CPU/GPIB board monitor voltage, current, power, frequency, and phase angle.

Voltage from the rear panel sense connector is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by an analog-to-digital converter.

Current sensed by internal current transformers is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

The scaled voltage and current waveforms are applied to the inputs of a multiplier. The multiplier output is filtered to a DC level and digitized by the analog-to-digital converter.

Frequency is computed from the measured time intervals between zero crossings of the Phase A waveform. Phase is computed from the differences of measured zero crossings between the Phase A signal and the Phase B or Phase C signal.

A digital-to-analog converter on the CPU/GPIB board sets the DC voltages that are used for the programmable current limit function.

5.4.3 PHASE A/REF BOARD

The Phase A/Ref board, A15, serves several purposes. A programmable clock sets the output frequency of the power source. Digital-to-analog converters program references to set the output amplitude of Phases A, B, and C. A sine wave generator creates a 1024 step waveform which is filtered to provide the Phase A oscillator signal. A remote sense amplifier controls the Phase A output amplitude and indicates a fault if it cannot maintain the output amplitude.

5.4.4 PHASE B/C BOARD

The Phase B/C board, A16, uses the DC voltage references and programmable clock from the Phase A/Ref board to generate the Phase B and C oscillator waveforms. Remote sense circuits control the Phase B and C output amplitudes and indicate faults if the amplitudes cannot be maintained.

5.4.5 DISPLAY BOARD

The Display board, A17, is held to the power source by a small panel and is connected through a short ribbon cable. It holds the 20 button keyboard and a 32 character LCD display. A knob on the board allows the display viewing angle to be adjusted.

5.4.6 OSCILLATOR EXTENDER

The Oscillator Extender, A12, mates the Programmable Power Controller module to the Control Mother board in the power source.

5.5 CONTROL MOTHER BOARD

The Control Mother board, A10, makes the necessary signal connections between the various assemblies of the power source. Figure 5-4 is a simplified schematic of the control mother board.

The Oscillator CPU connector accepts voltage and current sense signals for measurement, and optically isolated External Sync signals for frequency synchronization. Control and oscillator signals are sent out from this connector.

The Range Relay board connector sends out voltage and current sense signals and accepts relay control signals.

The Power Mother board connector accepts the oscillator signals and sources the DC supplies to rest of the power source.

The Indicator board accepts the necessary lines to light the lamps on the front panel.

The External System connector carries all the signals for the rear panel I/O. Note that the Function Strobe signal to this connector is optically isolated.

The Current Limit board connector accepts the current limit, current sense, and oscillator signals. The oscillator signals pass through potentiometers for gain adjustment. Leaving the connector are the modulated oscillator signals.

5.6 POWER MOTHER BOARD

The Power Mother board, A3, provides the high voltage and high current connections for the power amplifiers and DC supply. Figure 5-5 is a simplified schematic of the Power Mother board.

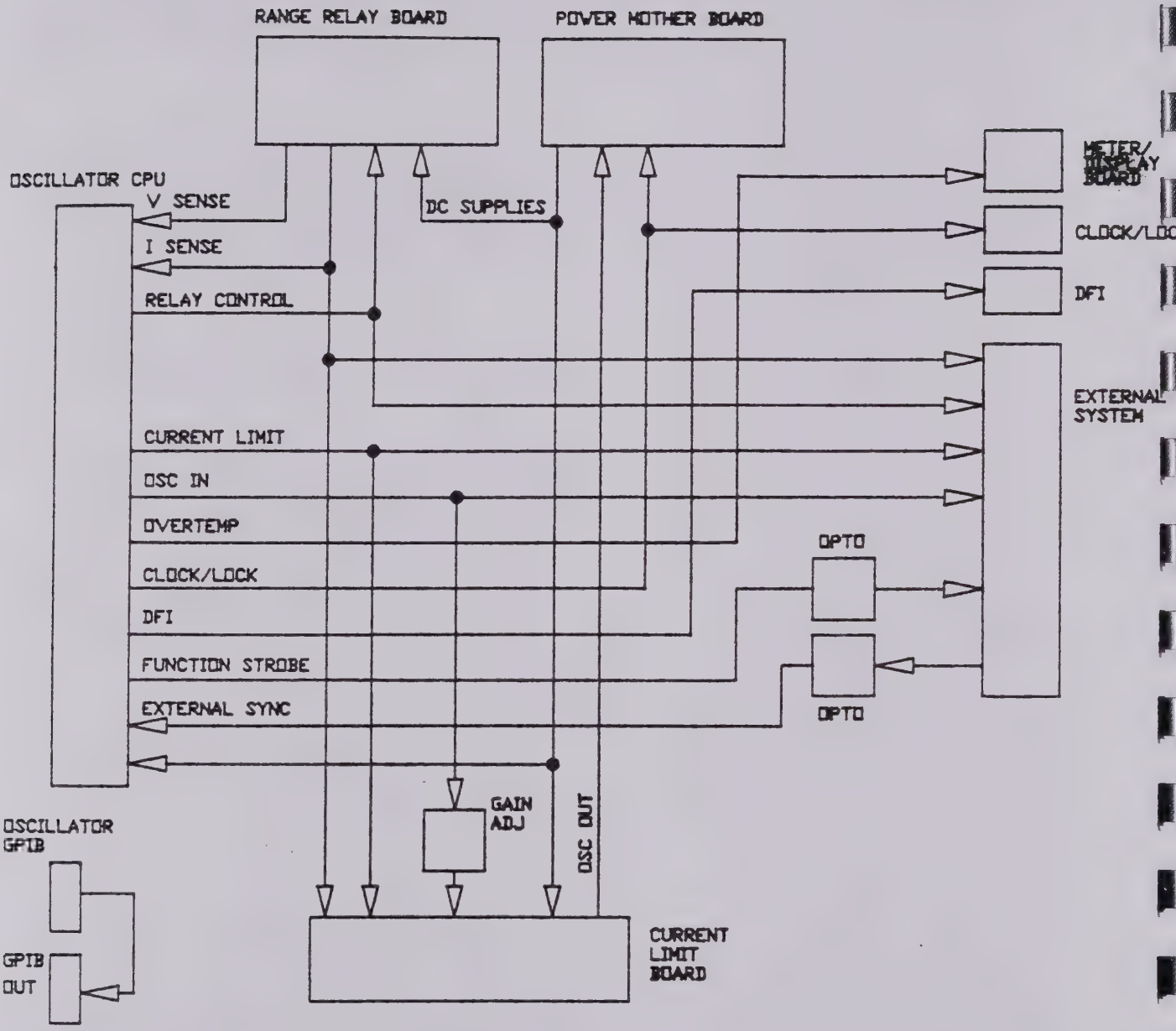


FIGURE 5-4 CONTROL MOTHER BOARD

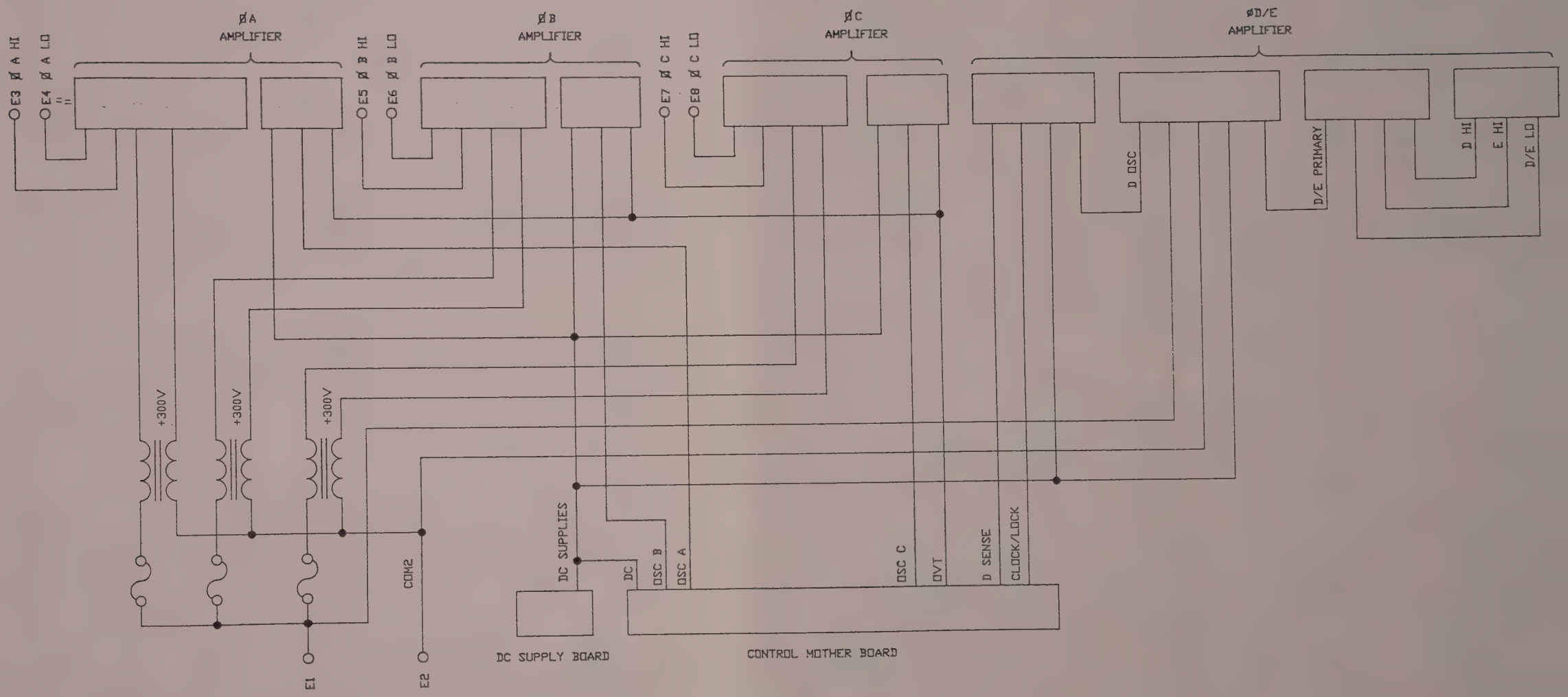


FIGURE 5-5 POWER MOTHER BOARD

The high voltage supply from the DC Supply board is connected at E1 and E2. The positive supply connection is divided into three lines, one per amplifier. Each of the lines is routed through a fuse and a filter inductor.

The DC Supply board plugs into the Power Mother board. It provides DC power to each of the amplifier control boards as well as the rest of the power source.

The Control Mother board connector accepts the DC supply lines and provides oscillator signals to each amplifier.

Each power amplifier module plugs into the Power Mother board through two connectors. One connector is dedicated to the high current supply and output wiring. The other connector provides the DC supplies and oscillator signals to the amplifier controller. Output power from each amplifier is directed to the Relay board through standoffs on the Power Mother board.

5.7 POWER AMPLIFIERS

There are three identical power amplifiers in the power source, A7, A8, and A9, one per phase. Each amplifier consists of a control board, a high power board and the power semiconductors. These components are mounted to a heat sink to form a Power Amplifier module. A description of the Power Amplifier module is given in the following paragraphs. Figure 5-6 shows a simplified schematic of the amplifier.

5.7.1 HIGH POWER BOARD

The high efficiency of the 1503L power source is attained because the amplifiers use switching technology. In the common, low efficiency class AB amplifier, transistors are used as variable resistance series pass elements. Transistors in class AB amplifiers act as voltage dividers between the amplifier power supply and its load. As the load draws more current, the transistors dissipate more power.

In the high efficiency switching amplifier, MOSFETs are used as switches; they are either turned on completely or turned off completely. This means that the transistors are always in a low power dissipation state. When the MOSFETs are on, they are passing high currents but with minimum voltage drop; when the MOSFETs are off, a high voltage is dropped across them but only leakage currents flow.

The L series amplifier is configured in the full bridge topology. In Figure 5-6 it is seen that the output is connected so as to bridge pairs of the switching transistors. The transistors are turned on and off as diagonal pairs; either A and B are turned on with C and D off, or C and D are turned on with A and B off.

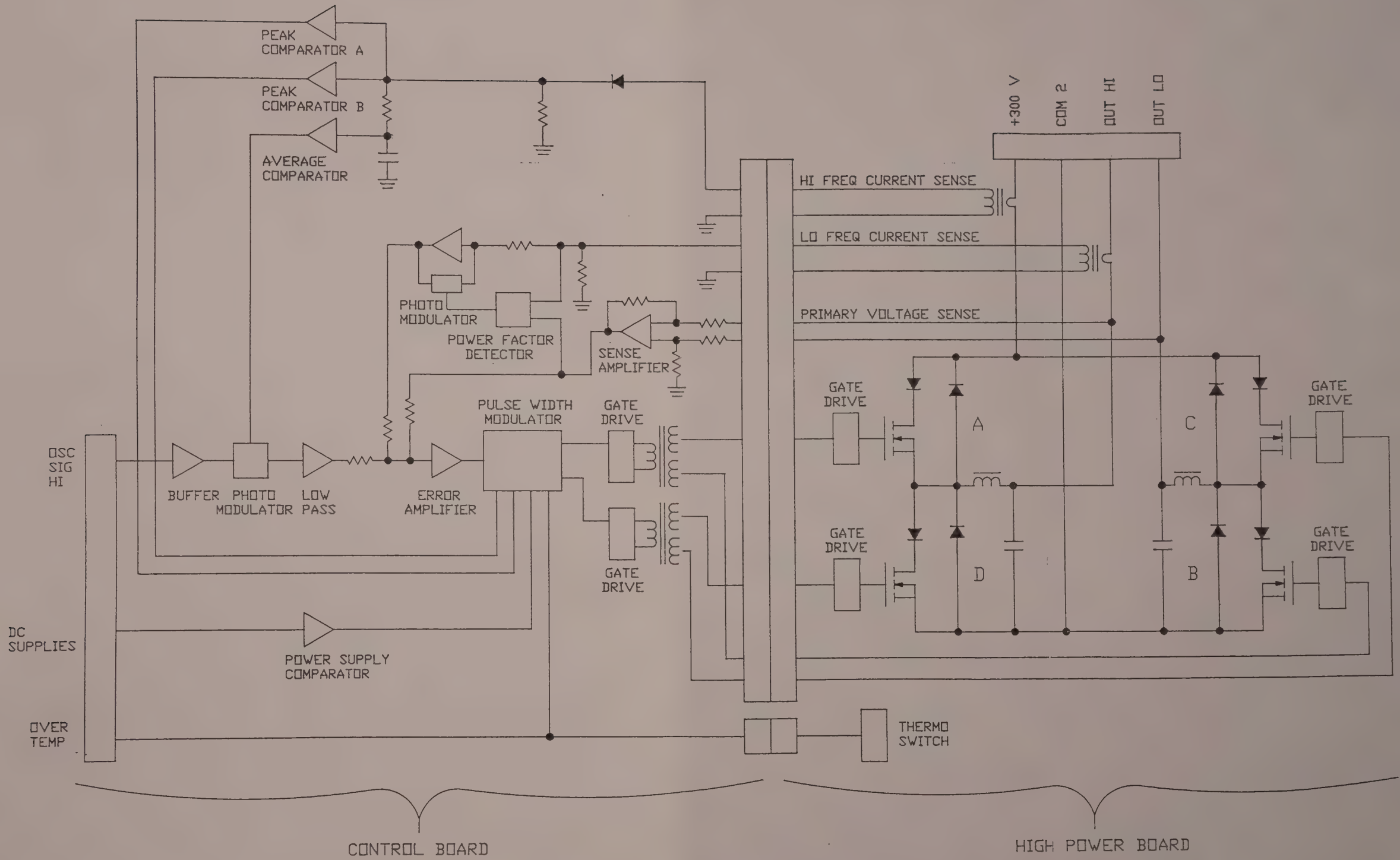


FIGURE 5-6 POWER AMPLIFIER

Switching the MOSFETs as diagonal pairs allows an alternating current to be generated from a single DC supply. When transistors A and B are on, OUT HI is pulled toward +300 V, OUT LO is pulled to COM 2 return. When transistors C and D are on, the situation is reversed; OUT LO is pulled to +300 V and OUT HI is pulled to COM 2.

A diode is connected in series with each of the switching transistors to block reverse current flow in the transistors. A diode in parallel with each series transistor-diode pair shunts reverse flowing currents around the pair.

Inductor-capacitor filters smooth the 200 KHz pulse waveform to pass only low frequency components to the output. This filtered output is sensed and sent to the Control board.

A high frequency current transformer senses the 200 KHz current pulses drawn by the amplifier. The current transformer output is used by the Control board to detect over-current conditions.

A low frequency current transformer senses the smoothed amplifier output current. The secondary voltage of this transformer is sent to the error amplifier on the Control board. This voltage boosts the amplifier output voltage slightly to make up for losses in the system as load current increases.

5.7.2 CONTROL BOARD

The main function of the Control board is to generate the gate drive signals for the High Power board. Other functions include overcurrent, overtemperature and power supply fault detection.

In Figure 5-6 the input OSC SIG HI signal enters the board on the left. This waveform is buffered, sent through a photomodulator and low pass filter. This filtered waveform is then sent to an error amplifier which drives the pulse-width modulator.

The pulse-width modulator samples the error amplifier's output to generate a 200 KHz, variable duty cycle pulse waveform. The amplifier output voltage is proportional to the duty cycle minus the complement of the duty cycle. Therefore, positive portions of the input signal cause duty cycles greater the 50%. Negative portions of the input signal cause duty cycles less than 50%. No input signal (zero volts) causes a duty cycle of exactly 50%.

The output of the pulse-width modulator drives two gate drive circuits. The output of each gate drive circuit is transformer coupled to the High Power board. The two secondaries of each transformer drive the two switches of a diagonal MOSFET pair. That is, the two secondaries of one gate drive transformer drive MOSFETs A and B; the two secondaries of the other transformer drive MOSFETs C and D.

The output voltage of the power amplifier is sensed by a differential amplifier which removes the high common mode voltage. The differential amplifier output is then fed to the error amplifier. This closes the feedback loop around the pulse-width modulator and full bridge amplifier.

The power amplifier output current is sensed by a low frequency current transformer on the High Power board. The sensed current is converted to a voltage, amplified, and sent to the error amplifier through an adjustment potentiometer. As load currents increase so will output voltage. This is to make up for the losses of the output transformer. The power factor of the load is detected and used to modify the amount of current feedback. Low power factor loads decrease the current feedback in order to increase amplifier stability.

The power amplifier switch current is sensed by a high frequency current transformer on the High Power board. The sensed current is converted to a voltage which is used for current fault protection. Three comparators use this current sense signal.

The first comparator is a peak current limiter. It acts to turn off the MOSFET switches on a pulse by pulse basis if the current crest factor goes beyond 2.5 of the maximum rms current.

A second peak comparator is set for a higher current than the first. It temporarily shuts down the pulse-width modulator so that no switch may turn on. This comparator protects against negative power factor loads.

The third comparator is an average current limiter. Its threshold is set lower than those of the previous two, but because an RC network is averaging the current sense signal, it acts more slowly than the peak current limiters. When an average current limit fault is detected, the comparator decreases drive to the photomodulator in series with the oscillator input signal. This causes the output waveform to be clipped.

A power supply comparator senses +15 VSW1 and shuts off the pulse-width modulator if the voltage is less than 11 volts DC. This is to protect the amplifier when power to the 1503L is switched on or off.

A thermoswitch mounted to the power amplifier heatsink is tripped at a heatsink temperature of approximately 100 degrees C. If activated, the pulse-width modulator is disabled until the heatsink cools down.

5.8 RANGE RELAY BOARD

The Range Relay board, A6, holds components to set the output voltage range, sense the output voltages and currents, and disconnect the outputs from the rear panel terminal block. Figure 5-7 is a simplified schematic of the Range Relay board.

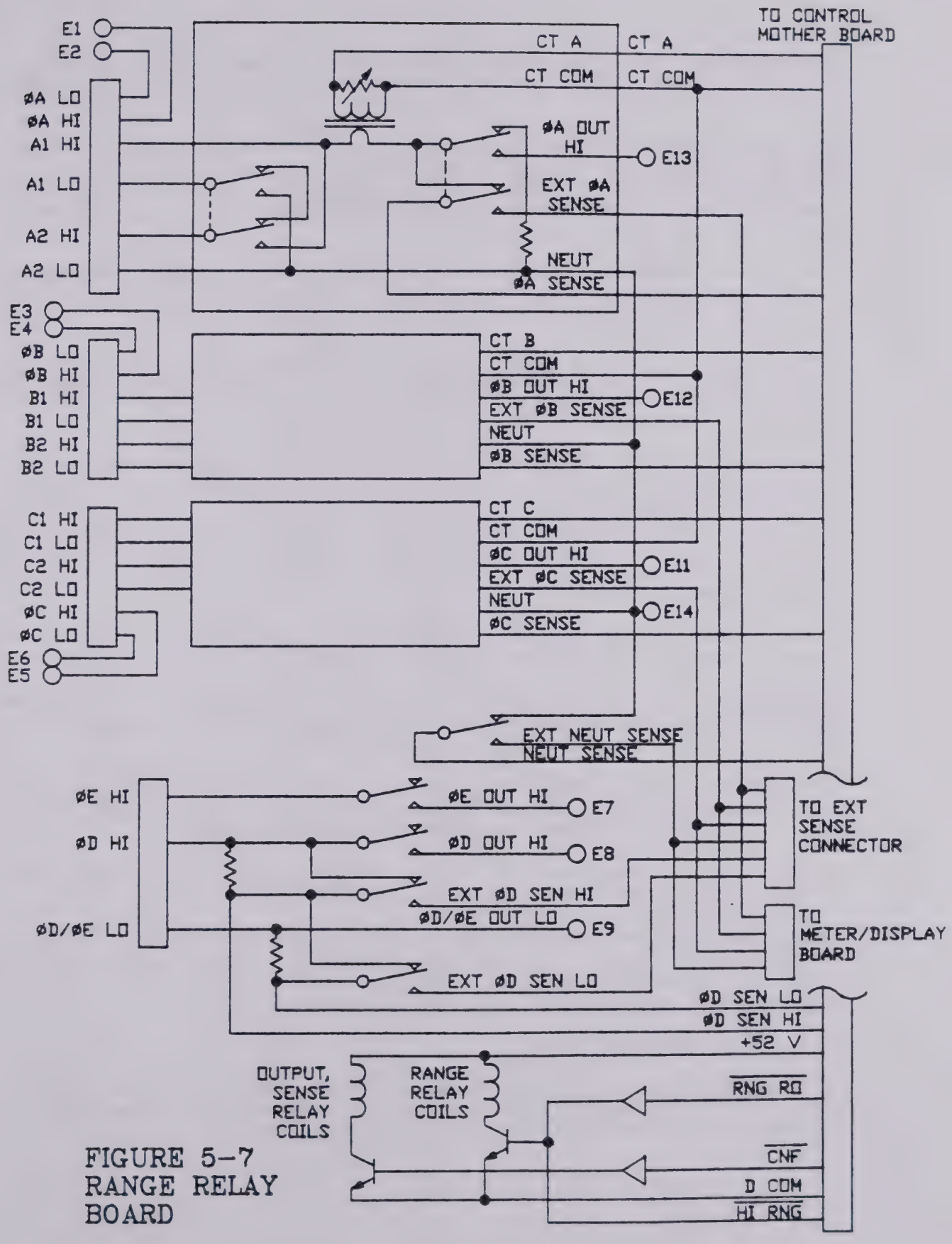


FIGURE 5-7
RANGE RELAY
BOARD

The circuits that implement these functions are similar for Phases A, B, and C, so they are only shown once, for Phase A, in Figure 5-7.

The output of the Phase A amplifier is connected from the Power Mother board to E1 and E2 on the Range Relay board and then to the output transformer primary via a connector on this board. The secondaries of the output transformer return to the Range Relay board on the same connector.

The secondaries are rated for 135 volts, 250 VA each. A double pole, double throw relay connects the secondaries in parallel for 135 volt operation or in series for 270 volt operation.

The HI output passes through the single turn primary of a current transformer. The secondary current of this transformer is converted to a voltage by a variable resistor. This voltage is used for output current and power measurement.

Two relays in each output circuit switch the output HIGH and the external sense line. The first relay switches the output between an internal mode and the output terminal block. The other relay switches the external sense point between an internal sense position and the rear panel terminal block. An additional relay switches the external neutral sense between an internal and an external sense point.

Circuits for range switching, output switching, and voltage and current sensing for Phases B and C operate in a similar manner.

If the AX option is installed, output switching relays are included for Phases D and E, and a remote sense relay is installed for Phase D.

The RNG R0 logic signal controls the range selection relays. When the signal is low, the high voltage range is chosen; when the RNG R0 signal is high, the low voltage range is chosen.

A buffered RNG R0 line, HI RNG, is used to drive the HIGH RANGE lamp on the 1503L front panel.

Output switch and remote sense relays are controlled by the CNF logic signal. When CNF is low, the output relays are open and internal sensing is active. When CNF is high, the output relays are closed, and external sensing is active.

5.9 METER/DISPLAY BOARD

A simplified schematic of the Meter/Display board, A1, is given in Figure 5-8. The board holds the front panel indicator lamps and the phase selector switch for the front panel meter.

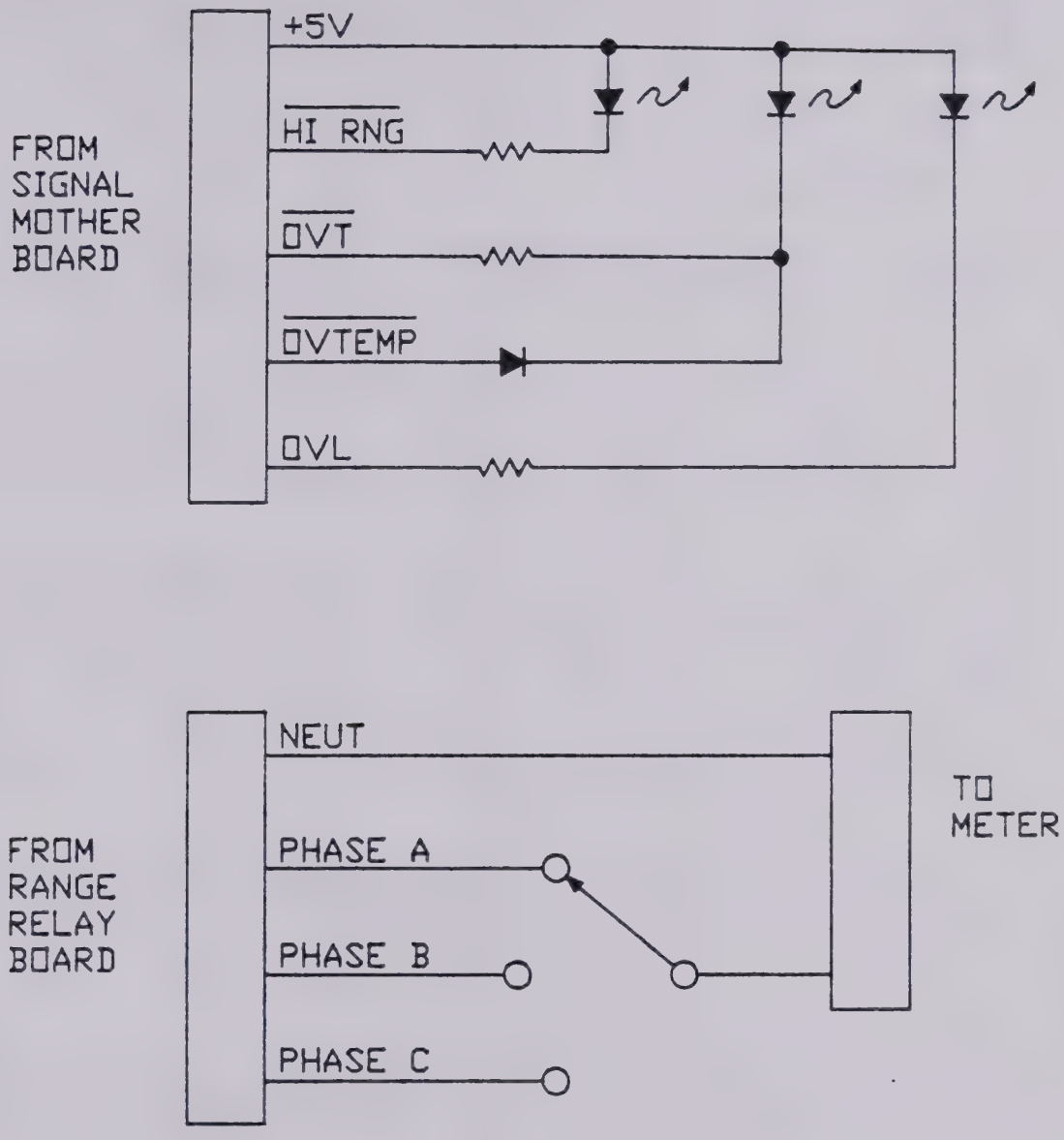


FIGURE 5-8 METER/DISPLAY BOARD

The HIGH RANGE function is indicated by an LED when the HI RNG line is pulled low. The OVERTEMP LED is lit when the OVT line is pulled low; this also pulls the OVTEMP line low, an indicator signal to the rest of the power source. The OVERLOAD LED is lit when a programmable current limit fault pulls the OVL line low.

A single pole, triple throw switch selects the Phase A or Phase B or Phase C output to drive the front panel meter.

5.10 CURRENT LIMIT BOARD

The Current Limit board, A11, modulates the oscillator waveforms to provide a programmable current limit function. A simplified schematic of this board is given in Figure 5-9.

The OSC A signal passes through a photomodulator before going to the power amplifier. The modulated signal is called PHASE A SIG HI. Normally the modulator is biased fully on and passes the OSC A signal to PHASE A SIG HI without changing it. During a programmable current limit fault, the modulator bias is reduced and the PHASE A SIG HI waveform is clipped.

An error amplifier controls the photomodulator. The inputs to this error amplifier are a programmable DC reference from the power controller and an averaged absolute value of the output current sense signal. The error amplifier adjusts the bias to the photomodulator in an attempt to maintain a difference of zero between the sensed output current and the programmed DC reference.

This error amplifier and photomodulator circuit is repeated for Phases B and C.

The outputs of each error amplifier are connected to the inputs of a NOR logic gate. When any error amplifier output goes high, the NOR output goes low pulling the OVL signal low. This illuminates the OVERLOAD LED on the front panel.

5.11 AX OPTION (Auxiliary Outputs)

The AX Option provides two additional outputs to the 1503L: a 26-volt, 3-amp Phase D output, and a 5-volt, 5-amp Phase E output. The option consists of two P.C. boards as well as cables and relays.

The first P.C. board, PH DE 1, is a switching amplifier similar to the Phase, A, B C amplifiers. The theory of operation is the same as described in Section 5.7 except that there is no LO FREQ current sense circuit or thermoswitch circuit and all circuits are included on one P.C. board. See Figure 5-10 for a simplified schematic.

The second P.C. board, PH DE 2, includes a sine wave generator, an error amplifier and an output transformer. A simplified schematic is given in Figure 5-11.

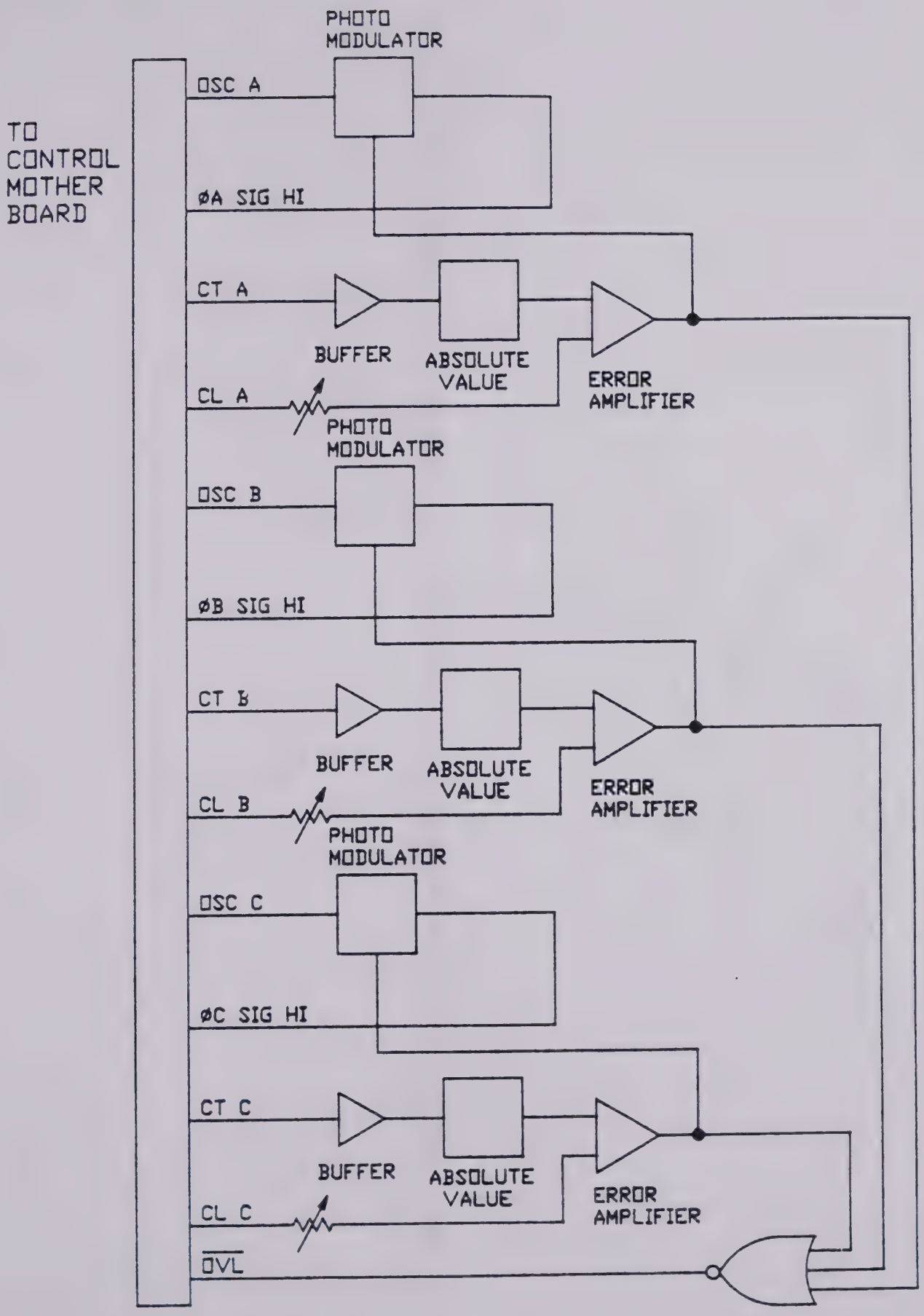


FIGURE 5-9 CURRENT LIMIT BOARD

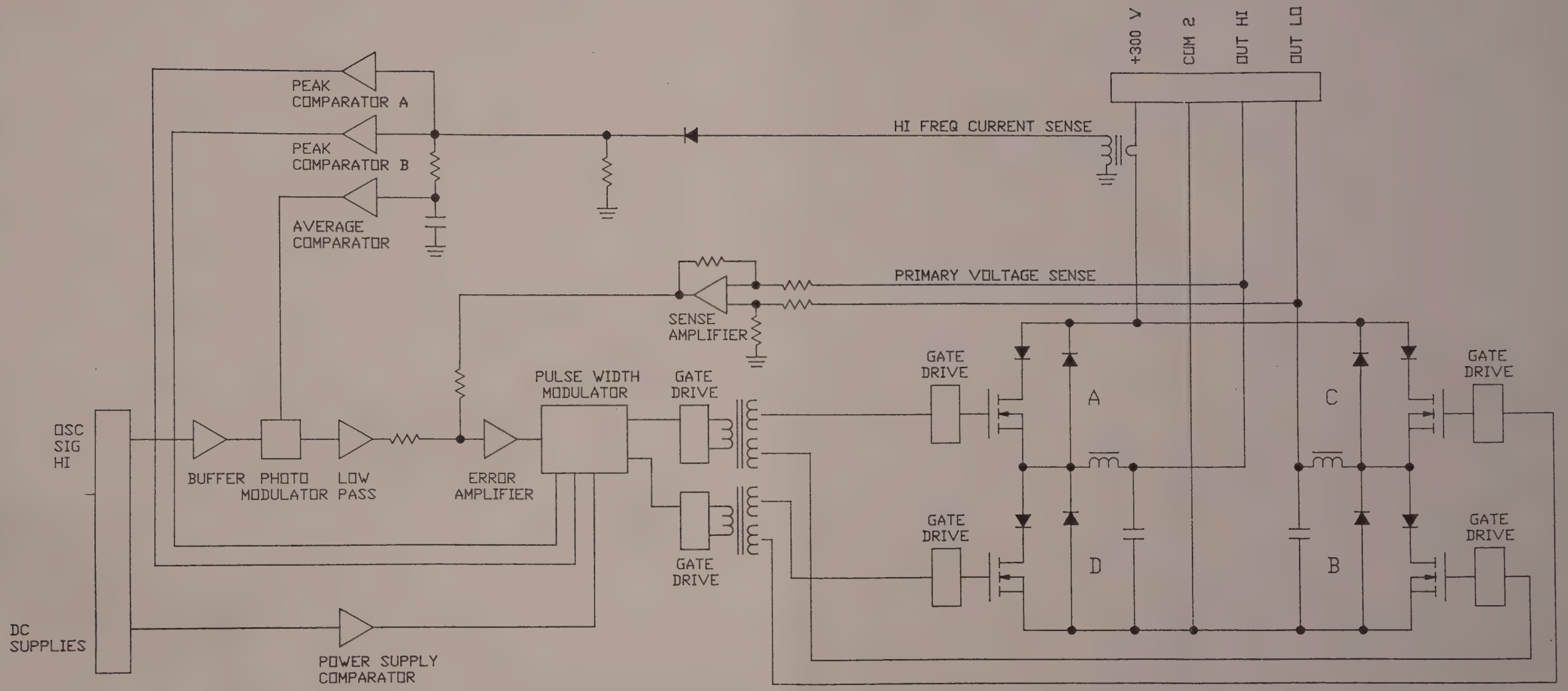


FIGURE 5-10 SWITCHING AMP ØDE1

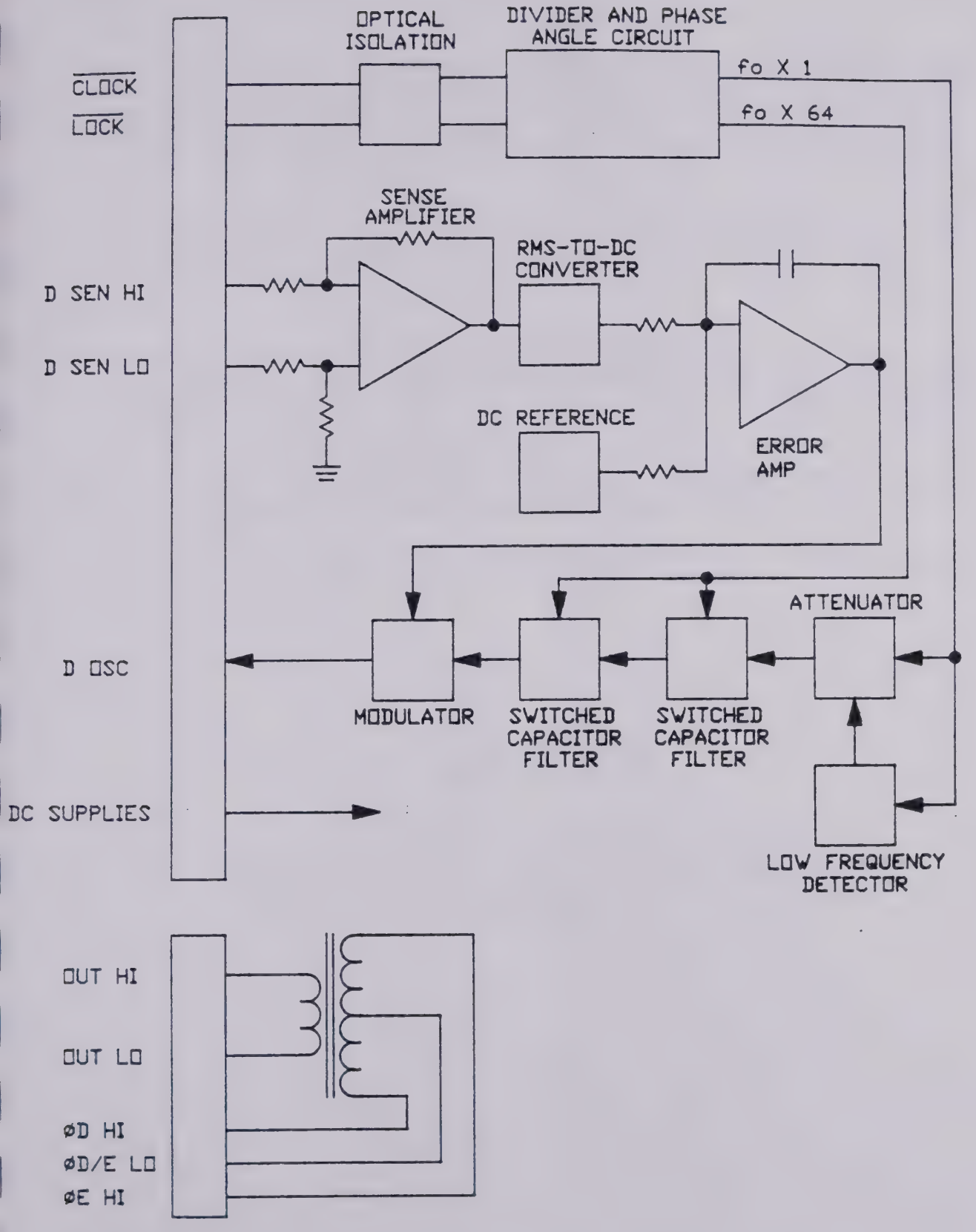


FIGURE 5-11 SWITCHING AMP øDE2

The CLOCK line drives the sine wave generator. CLOCK is a logic signal switching at 1024 times the output frequency. A divider circuit generates the output frequency. The LOCK signal is a logic signal switching at the output frequency. It is used to load variable divider presets to allow for phase adjustment of the oscillator output.

The output frequency logic signal from the divider is applied to two cascaded switched capacitor filters. These 4-pole filters are clocked at 64 times the output frequency and attenuate overtones of the logic signal to leave a low distortion sine wave oscillator output.

The Phase D HI and LO outputs are allied to a differential sense amplifier and then converted to DC by a true-rms-converter. This DC sense signal is compared to a DC reference by an integrating error amplifier. The output of the error amplifier controls a modulator so that the Phase D output is maintained at 26 volts rms.

The Phase DE 2 board also holds an output transformer that converts the 100 volt primary to a 26 volt and a 5 volt secondary.

A low frequency detector switches off the output for frequencies below 300 Hz to prevent output transformer saturation.

CAUTION

Voltages up to 480 VAC are available in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied.

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures for the 1503L. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section.

TABLE 6-1

PARAGRAPH	PROBLEM	PAGE
6.3.1	Poor Voltage Accuracy/Regulation	134
6.3.2	Overtemperature Lamp On	135
6.3.3	Overload Lamp On	135
6.3.4	Programmable Power Controller Configuration Wrong	135
6.3.5	Can't Program Power Source On GPIB	136
6.3.6	Power Source Output Distorted	136
6.3.7	No Power Source Output	137
6.3.8	Programmable Power Controller Error Messages	138

6.2 MAINTENANCE

The California Instruments 1503L is a solid state unit and should require a minimum of maintenance. However, the power source is forced-air cooled and will accumulate dust with time. Dust on the power source ventilation holes should be removed as necessary.

6.3 TROUBLESHOOTING

If the 1503L power source does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

6.3.1 POOR VOLTAGE ACCURACY/REGULATION

If the power source exhibits poor programmed voltage accuracy, poor line regulation, or poor load regulation, the following item may be at fault:

1. Voltage sense lines are disconnected or incorrectly connected.

   SOLUTION: Connect voltage sense lines. See Section 2.6.2.

6.3.2 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following items may be at fault:

1. Ambient temperature is too high.

   SOLUTION: Operate power source between 0 and 50°C.

2. Fan or ventilation holes are blocked.

   SOLUTION: Remove obstructions.

3. Fan not working.

   SOLUTION: Replace fan. Consult factory.

6.3.3 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the output load current has exceeded the programmable current limit set level. If the power source OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

   SOLUTION: Remove the overload.

2. The programmable current limit level is set too low for the load being driven.

   SOLUTION: Compute and reprogram the correct programmable current limit level.

6.3.4 PROGRAMMABLE POWER CONTROLLER CONFIGURATION WRONG

If the programmable power controller configuration data has become corrupted, the power controller may be set to single phase output operation, may have lost all measurement calibration, may have lost output amplitude accuracy calibration, or may not allow front panel or bus programming.

SOLUTION: Consult factory to reconfigure/recalibrate the programmable power controller.

6.3.5 CAN'T PROGRAM POWER SOURCE ON GPIB

If the power source does not respond to IEEE-488 GPIB programming, the following items may be at fault:

1. The power source unit address is wrong.

   SOLUTION: Update address. See Section 3.10.

2. GPIB cable is loose at power source rear panel.

   SOLUTION: Check connection, tighten jack screws.

3. Programmable power controller has failed.

   SOLUTION: Replace programmable power controller. See Section 6.4.1.

6.3.6 POWER SOURCE OUTPUT DISTORTED

If the power source output is distorted from a sine waveform, the following items may be at fault:

1. The power source output is overloaded.

   SOLUTION: Remove overload. Observe power source capabilities. See Section 1.

2. The output is being clipped by the programmable current limiter.

   SOLUTION: Programmable current limit level is set too low. Compute and reprogram the correct programmable current limit level.

3. Power source input is similarly distorted. Check the oscillator signals with oscilloscope at the system interface connector:

J7-24	Oscillator Phase A
J7-6	Oscillator Phase B
J7-23	Oscillator Phase C
J7-7	Oscillator common/return

   SOLUTION: If the power source is not configured with an internal power controller, the oscillator signals are being provided externally on pins listed above. Provide an undistorted input.

   SOLUTION: If the power source is configured with an internal power controller, the power controller has failed. Replace the power controller. See Section 6.4.1

6.3.7 NO POWER SOURCE OUTPUT

If power source provides no output at the rear panel terminal block TB-2, the following items may be at fault:

1. The output is overloaded. If the programmable power controller cannot maintain correct output voltage because of an overload, the power controller will set the output voltages to the default value and open the confidence/output application relays.

   SOLUTION: Remove overload. Observe power source capabilities. See Section 1.

2. The power source has detected an overtemperature condition. If the programmable power controller detects an overtemperature fault, the power controller will set the output voltages to the default value and open the confidence/output application relays.

   SOLUTION: See Section 6.3.2.

3. The confidence/output application relays are open.

   SOLUTION: The CNF line, J7-11 on the rear panel, must be pulled high. This line is pulled up internally; remove any connection that would pull the line down to D COM.

   SOLUTION: If the power source has an internal power controller under local keypad control, the CNF line is controlled automatically. Check that J7-11 on the rear panel is at +5 volts DC with respect to J7-27. If not, the power controller has failed. Replace power controller. See Section 6.4.1.

   SOLUTION: If the power source has an internal power controller under IEEE-488 GPIB control, the confidence/output application relays must be programmed to close. See Section 3 for appropriate programming information.

4. The REMOTE ON, J7-29 on the system interface, is pulled low.

   SOLUTION: The REMOTE ON line is pulled to +5 volts DC internally. Remove any connection on the rear panel that pulls this line low.

5. The power source has no input signal. Check the oscillator signals with oscilloscope at the system interface connector:

J7-24	Oscillator Phase A
J7-6	Oscillator Phase B
J7-23	Oscillator Phase C
J7-7	Oscillator common/return

For full scale output these signals must be at 5 volts rms.

SOLUTION: If the power source has no internal power controller, these signals must be provided on rear panel system interface connector, J7. Provide correct signals.

SOLUTION: If the power source is configured with an internal power controller, verify that outputs are correctly programmed. If the power controller is correctly programmed but is not generating oscillator signals, the controller has failed. Replace power controller. See Section 6.4.1.

6. The amplifier has failed in the power source.

SOLUTION: See Section 6.4.2.

7. One of the internal DC supplies has failed.

SOLUTION: See Section 6.4.3.

6.3.8 PROGRAMMABLE POWER CONTROLLER ERROR MESSAGES

The following is a list of possible programmable power controller error messages and an explanation of each.

6.3.8.1 AMP A & B & C FAULT

The power controller has been unable to hold one or more of the three phases at their programmed value.

6.3.8.2 TEMP A & B & C FAULT

The power controller has detected the loss of output of one or more phases due to an overtemperature condition.

6.3.8.3 CPU MEMORY FAULT

The power controller has detected a fault in its internal memory.

6.3.8.4 DMA OVERFLOW

More than 256 bytes have been sent to the DMA buffer.

6.3.8.5 DIV ERROR

The power controller has detected an internal CPU fault.

6.3.8.6 OVERFLOW ERROR

The power controller has detected an internal CPU fault.

6.3.8.7 EXT SYNC ERROR

The frequency of the EXT SYNC signal is less than 45 Hz or greater than 5000 Hz.

6.3.8.8 BUS LOCAL ERROR

An attempt has been made to program the power controller over the IEEE-488 GPIB without asserting the GPIB REN line.

6.3.8.9 SYNTAX ERROR

A command string has been sent that does not meet the 1503L power controller syntax requirements.

6.3.8.10 AMP RANGE ERROR

An attempt has been made to program an amplitude to a value greater than the RNG limit.

6.3.8.11 FRQ RANGE ERROR

An attempt has been made to program the frequency to less than 45 Hz or greater than 5000 Hz.

6.3.8.12 PHZ RANGE ERROR

An attempt has been made to program a phase to a value greater than 999.9 degrees.

6.3.8.13 CRL RANGE ERROR

An attempt has been made to set the programmable current limit level to a value greater than 4.260 amps.

6.3.8.14 RMP RANGE ERROR

An attempt has been made to program a ramp that cannot be executed because of range or resolution limitations.

6.4 MODULE TESTING AND REPLACEMENT

6.4.1 PROGRAMMABLE POWER CONTROLLER REMOVAL/REPLACEMENT

If a fault has been found that requires the replacement of the programmable power controller module (Oscillator Module Assembly 4008-407), use the following procedure. See Figure 6-1.

1. Disconnect line power at the 1503L input TB-1.
2. Remove the power source top cover.
3. Remove the #6 screw on the bottom of the chassis near the front panel.
4. Loosen the three #6 screws that hold the module in place. Do not remove these screws, they serve to retain several spacers.
5. Lift the module from the chassis unplugging it from the small Oscillator Extender assembly (4008-707).
6. Unplug the ribbon cable between the module and the keyboard/display.
7. Hold the three long screws in place on the module with three #6-32 nuts.
8. Remove the keyboard display by loosening the two captive screws on its front panel.
9. Remove the Oscillator Extender assembly (4008-707).
10. The module is now removed. The complete module assembly consists of the oscillator extender, the module, and the keyboard display.
11. The module may be replaced using the reverse of these steps.

6.4.2 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that requires the replacement of an amplifier module (Amplifier Assembly 4008-410), use the following procedure. See Figure 6-2.

There are three identical amplifiers in the power source, one for each phase. Phase A is the top amplifier, Phase B is the middle amplifier, and Phase C is the bottom amplifier.

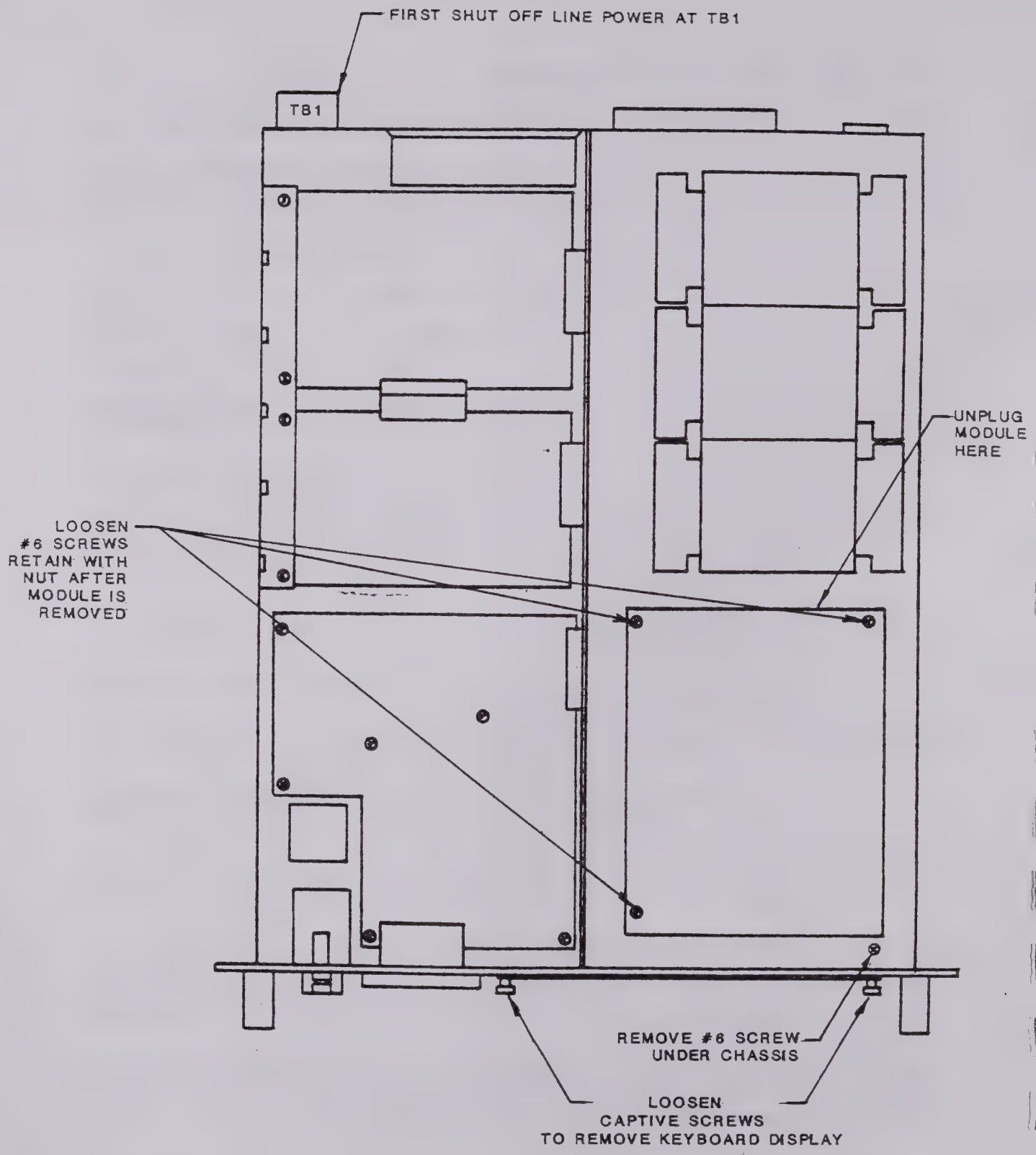

FIRST SHUT OFF LINE POWER AT TB1
TB1
UNPLUG MODULE HERE
LOOSEN #6 SCREWS RETAIN WITH NUT AFTER MODULE IS REMOVED
REMOVE #6 SCREW UNDER CHASSIS
LOOSEN CAPTIVE SCREWS TO REMOVE KEYBOARD DISPLAY

FIGURE 6-1

PROGRAMMABLE POWER CONTROLLER REMOVAL

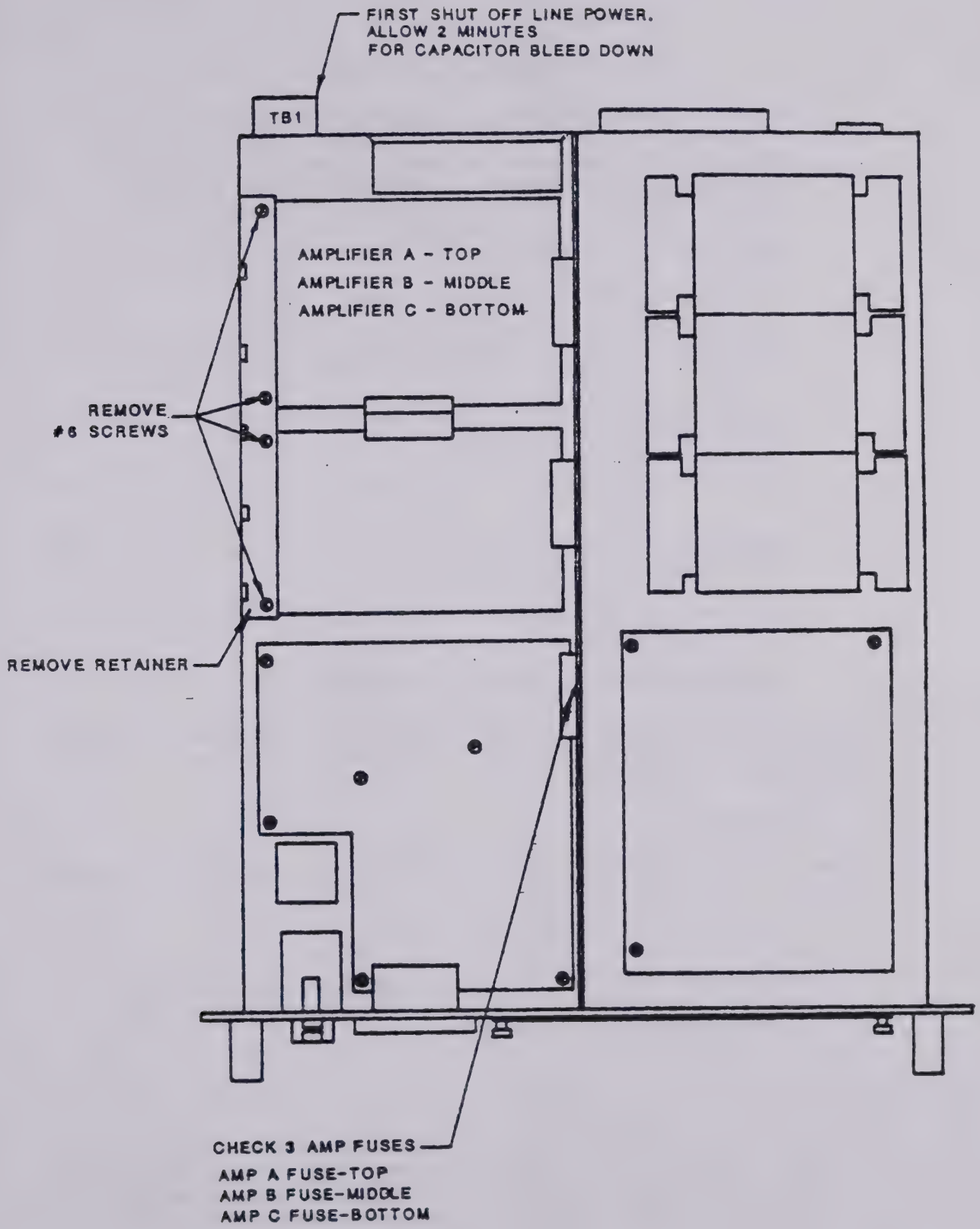


FIGURE 6-2

AMPLIFIER REMOVAL

WARNING

Filter capacitors on the amplifier assemblies may be charged to 360 volts DC. These capacitors are bled down by resistors on the DC Supply module. Do not attempt to remove an amplifier until it has been allowed to discharge for at least two minutes.

1. Disconnect line power at the 1503L input TB-1.

2. Remove the power source top cover.

3. Remove the four #6 screws that hold the insulating retainer in place. Remove the retainer.

4. Remove the amplifier by sliding it towards the left side of the chassis and lifting it out.

5. The amplifier may be replaced using the reverse of these steps.

6. Check the amplifier's associated 3 amp fuse. See Figure 6-2. Replace fuse if blown.

7. After an amplifier has been replaced, recalibrate its gain potentiometer. See Section 4.

6.4.3 DC SUPPLY TESTING/REMOVAL/REPLACEMENT

If a fault has been found that requires the replacement of the DC Supply module (DC Supply Assembly 4008-712), use the following procedure. See Figure 6-3.

6.4.3.1 TESTING

Use these tests to verify that the DC supply module is working correctly.

WARNING

Component voltages on the DC supply may reach 750 volts. Use caution not to touch uninsulated components and heat sinks.

WARNING

The high voltage supply on the DC supply module may be floating by as much as 200 volts above earth/chassis ground. Do not use an oscilloscope or other test instrument that may short any supply test point to earth/chassis ground.

1. Turn the power source off.

2. Remove the power source top cover.

3. Turn the power source on and measure the following power supply DC voltages, see Figure 6-4.

TEST POINT	REFERENCE	DC VOLTAGE RANGE
TP-19	TP-18	+245 to +360
TP-1	TP-2	+18 to +31
TP-3	TP-2	-18 to -31
TP-4	TP-2	+8.5 to +14
TP-17	TP-2	+4.8 to +5.2
TP-5	TP-6	+8.0 to +14
TP-7	TP-6	+15 to +25
TP-8	TP-6	-15 to -25
TP-16	TP-6	+13 to +16
TP-11	TP-12	+48 to +55

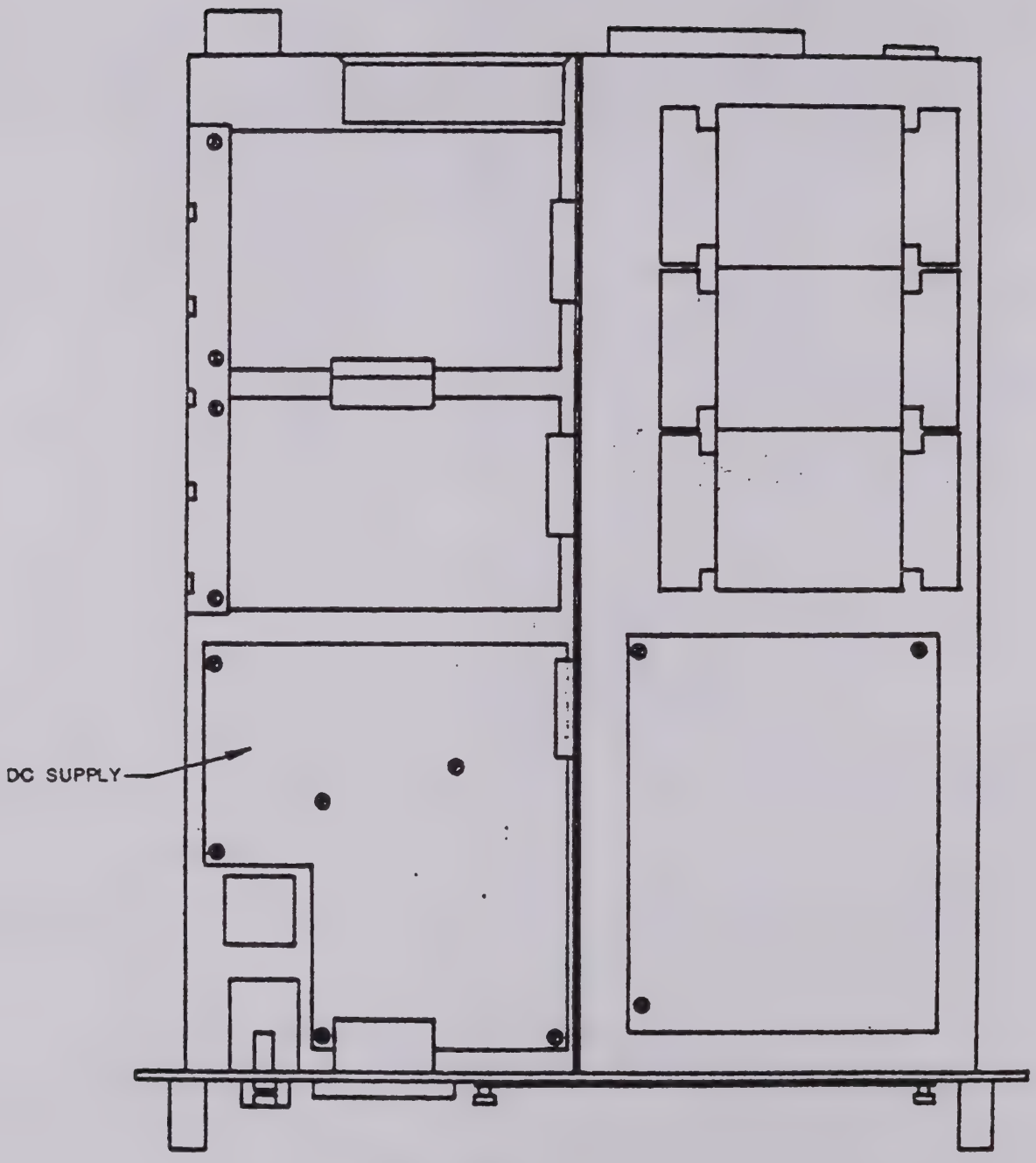


FIGURE 6-3
DC SUPPLY LOCATION

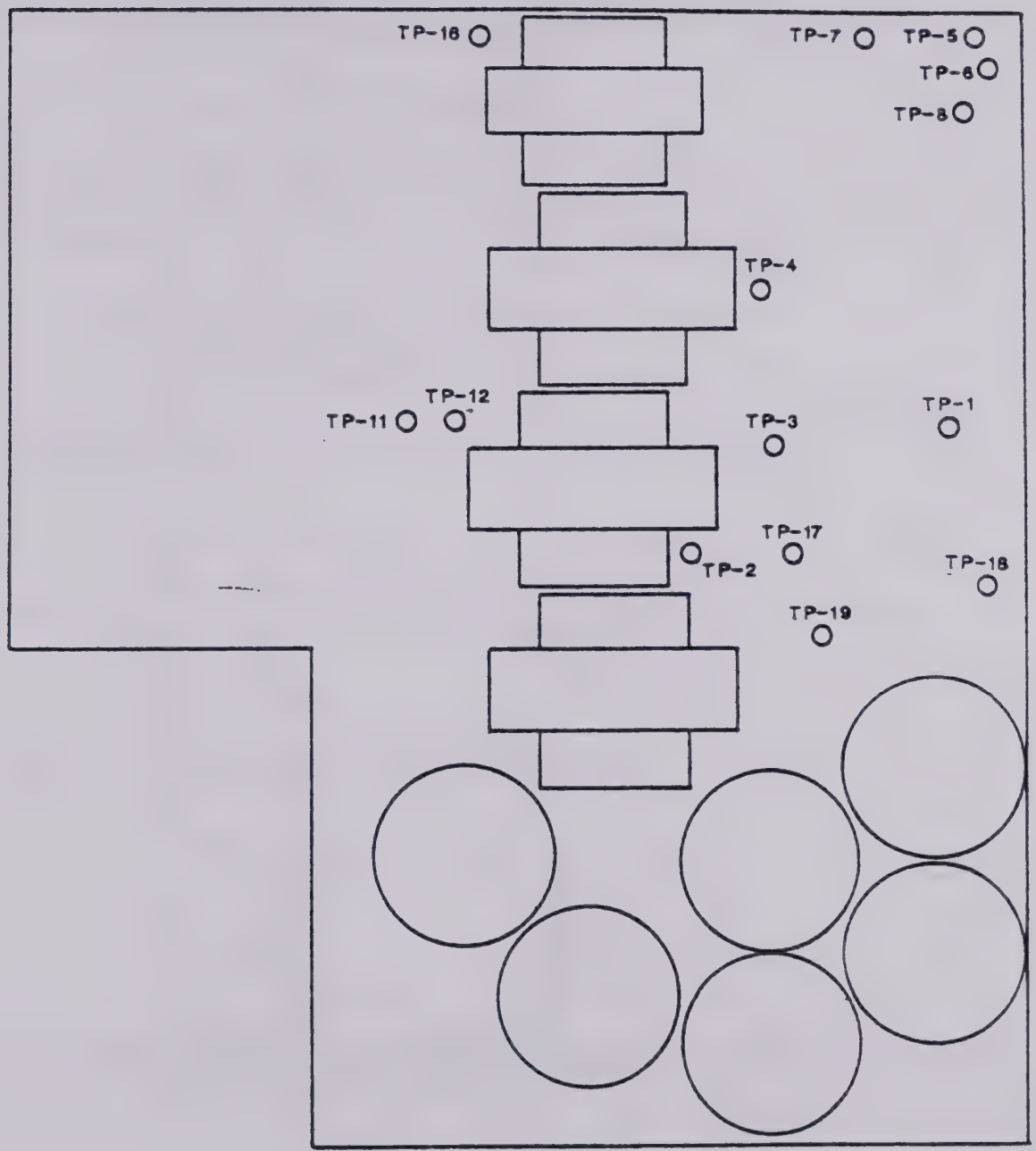


FIGURE 8-4

DC SUPPLY TEST POINTS

6.4.3.2 REMOVAL/REPLACEMENT

If one or more of the supply voltages have failed, the DC supply module must be replaced. Use the following procedure for removal and replacement. See Figure 6-5.

WARNING

Filter capacitors on the DC supply module may be charged to 360 volts DC. These capacitors are bled down by resistors on the module. Do not attempt to remove the module until it has been allowed to discharge for at least two minutes.

1. Disconnect line power at the 1503L input TB-1.

2. Remove the power source top cover.

3. If the power source is configured for the low input voltage range the following wires must be removed from the DC supply:

WIRE #	DC SUPPLY POINT
4008-050-007	E1
4008-050-005	E2
4008-050-006	E3
4008-050-009,010	E5
4008-050-008	E6
4008-050-011	E7

4. If the power source is configured for the high input voltage range the following wires must be removed from the DC supply:

WIRE #	DC SUPPLY POINT
4008-050-007	E1
4008-050-006	E3
4008-050-011	E4
4008-050-009,010	E5
4008-050-008	E6

5. Disconnect the lead marked E11 on the DC supply at E1 on the power source mother board. Disconnect the lead marked E12 on the DC supply at E2 on the power source mother board.

6. Remove the 6 #8 screws that hold the DC supply in place.

7. Unplug and lift the DC supply module from the power source.

8. The module may be replaced by using the reverse of these steps. Reconfigure the input voltage range of the DC supply module if necessary. See Section 2.3.

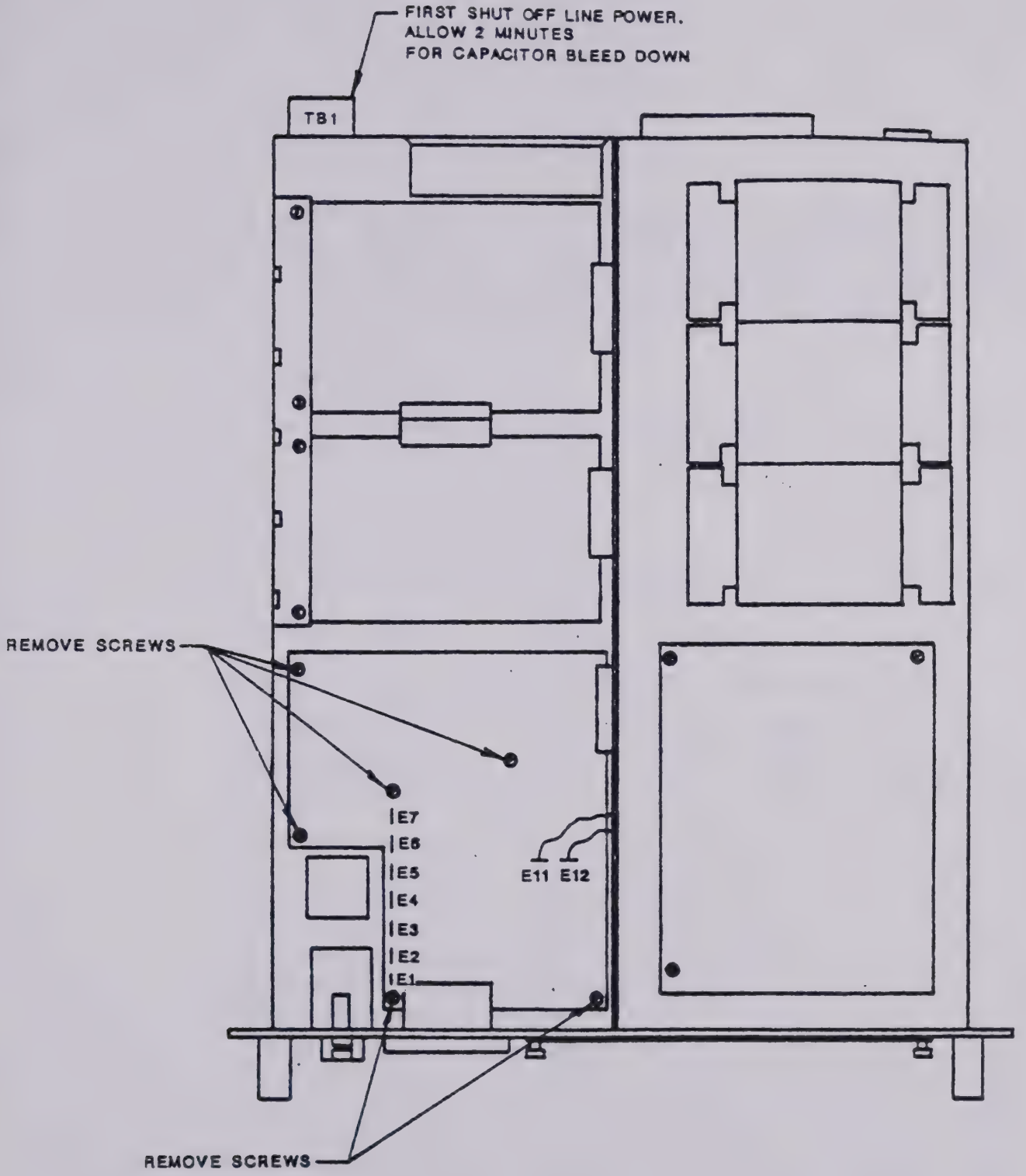


FIGURE 6-5

DC SUPPLY REMOVAL

SECTION 7

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and a complete list of replaceable parts. The parts are listed by their major assembly in alpha-numeric order by their reference designators. The list includes the parts description, manufacturers' identification (see Appendix A for list of manufacturers), and California Instruments' part numbers.

7.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable, for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the subassembly where component is located (PARENT ITEM NO.).

c. Component reference designator (SEQ NO.).

d. Component description (DESCRIPTION TRUNCATED).

e. Component manufacturer's FSCM number (VENDOR).

f. California Instruments part number (COMPONENT ITEM NO.).

All replacement part orders should be addressed to:

California Instruments
Attention: Parts Department
9689 Towne Centre Drive
San Diego, California 92121

TOP ASSEMBLY REPLACEABLE PARTS
FOR 1503L-3P
TOP ASSEMBLY NO: 4008-409-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4008-711-1	PC ASSY, METER/DISPLAY	16067	1.0
A3	4008-715-1	PC ASSY, MOTHER POWER	16067	1.0
A4	4008-712-1	PC ASSY, DC SUPPLY	16067	1.0
A6	4008-718-1	PC ASSY, RANGE/RELAY	16067	1.0
A7	4008-410-1	AMPLIFIER ASSY,PHASE ABC	16067	1.0
A8	4008-410-1	AMPLIFIER ASSY,PHASE ABC	16067	1.0
A9	4008-410-1	AMPLIFIER ASSY,PHASE ABC	16067	1.0
A10	4008-720-1	PC ASSY,MOTHER,CONTROL	16067	1.0
A11	4008-719-1	PC ASSY,CURRENT LIMIT	16067	1.0
A12	4008-707-1	PC ASSY,EXTENDER,OSC	16067	1.0
A20	4008-411-3	MODULE ASSY,OSC,3P	16067	1.0
B1	241175	FAN, 4", 48VDC,	60399	1.0
F1	270156	FUSE,3A,250V	75915	1.0
F2	270156	FUSE,3A,250V	75915	1.0
F3	270156	FUSE,3A,250V	75915	1.0

SECTION 8

MIL-STD-704D

8.1 GENERAL

The MIL-704D option is capable of performing all sections of MIL-STD-704D. It will perform all tests in the order listed below or part of the test. There is a 5 second delay between tests to allow the operator to evaluate the result of the test.

8.2 INITIAL SETUP

Nominal parameters for the AC Power Source shall be as follows:

OUTPUT VOLTAGE:	115 L-N
OUTPUT FREQUENCY:	400
OUTPUT PHASE ANGLE:	B 240 C 120

8.3 TEST PERFORMED

8.3.1 Steady state test. (Refer to MIL-704D Doc. Table 1)

1. Voltage per Figure 1, page
2. Voltage unbalance per Figure 2, page
3. Voltage phase difference per Figure 3, page
4. Waveform distortion factor per Figure 4, page
5. Frequency per Figure 5, page

8.3.2 Transient

1. Voltage Transient (Refer to MIL-704D Doc. Figure 5.)
   High voltage Transient per Figure 6, page
   Low voltage Transient per Figure 7, page

2. Frequency Transient (Refer to MIL-704D Doc. Figure 6)
   High frequency Transient per Figure 8, page
   Low frequency Transient per Figure 9, page

8.3.3 Abnormal operation

1. Abnormal voltage (Refer to MIL-704D Doc. Figure 7).
   Overvoltage per Figure 10, page
   Undervoltage per Figure 11, page

2. Abnormal frequency (Refer to MIL-704D Doc. Figure 8)
   Overfrequency per Figure 12, page
   Underfrequency per Figure 13, page

8.3.4 Emergency operation (Refer to MIL-704D Doc. 5.2.5)

1. Voltage per Figure 14, page
2. Frequency per Figure 15, page

8.4 KEYPAD ENTRY (Refer to page for Keyboard flow chart)

To perform a test from the key board, the following key sequence is required:

704 ENT

The following screen will appear:

MIL704D:SelA,B,C
ENT=all CLR=EXIT

Pressing the A, B, C or any combination selects the phase in test. Press ENT without the phase select for simultaneous three-phase test.

The following screen appears for a short time.

TEST A,B,C
CLR to Reselect

The next screen is:

Apply Nom Output
Press ENT

When ENT is selected the following screen appears:

Press MNU to
Select Test

The MNU screen has two lines of selection shown at a time.

There are 3 different types of operations that can be selected from a MENU screen. If the word MENU appears for the item selected, another MENU screen will be displayed. If the word TEST appears fir the item selected, the test will start. The display will return to the previous screen if the word RETURN appears for the item selected.

The Main Menu will appear as follows:

1=Steady St Menu
2=Transient Menu
3=Abnormal Menu
4=Emergency Menu
5=MIL704D Test
6=Return

If key 1 is selected "Steady State: from the Main Menu, the following Menu will appear:

1=Voltage Test
2=Unbalance Test
3=Phase dif Test
4=Wave dist Test
5=Frequency Test
6=Steady St Test
7=Return

If key 2 is selected "Transient" from the Main Menu, the following Menu will appear:

1=Volt Trns Menu
2=Freq Trns Menu
3=Transient Test
4=Return

If key 1 is selected from the Transient Menu the following Menu will appear:

1=High Volt Test
2=Low Volt Test
3=Volt Trns Test
4=Return

If key 2 is selected from the Transient Menu the following Menu will appear:

1=High Freq Test
2=Low Freq Test
3=Freq Trns Test
4=Return

If key 3 is selected "Abnormal" from the Main Menu, the following Menu will appear:

1=Abnl Volt Menu
2=Abnl Freq Menu
3=Abnormal Test
4=Return to Main Menu

If key 1 is selected from the "Abnormal" Menu, the following Menu will appear:

```
1=Overvolt Test
2=Undervolt Test
3=Abnl Volt Test
4=Return
```

If key 2 is selected from the "Abnormal" menu, the following Menu will appear:

```
1=Overfreq Test
2=Underfreq Test
3=Abnl Freq Test
4=Return
```

If key 4 is selected "Emergency" from the Main Menu, the following Menu will appear:

```
1=Emrg Volt Test
2=Emrg Freq Test
3=Emergency Test
4=Return
```

8.5 GPIB OPERATION (Refer to page for syntax diagram)

The following command will be used to execute the appropriate part of all of the test.

```
MIL704D[A][B][C]                    Test all MIL704D Sections
MIL704D[A][B][C] :STEady state
MIL704D[A][B][C] :STEady state :VOLTage
MIL704D[A][B][C] :STEady state :VOLTage :UNBalance
MIL704D[A][B][C] :STEady state :PHASe :DIFFerence
MIL704D[A][B][C] :STEady state :WAVeform :DISTortion
MIL704D :STEady state :FREQuency

MIL704D[A][B][C] :TRANsient
MIL704D[A][B][C] :TRANsient :VOLTage
MIL704D[A][B][C] :TRANsient :VOLTage :HIGH
MIL704D[A][B][C] :TRANsient :VOLTage :LOW
MIL704D :TRANsient :FREQuency
MIL704D :TRANsient :FREQuency:HIGH
MIL704D :TRANsient :FREQuency:LOW

MIL704D[A][B][C] :ABNormal
MIL704D[A][B][C] :ABNormal :VOLTage
MIL704D[A][B][C] :ABNormal :VOLTage :OVER
MIL704D[A][B][C] :ABNormal :VOLTage :UNDer
MIL704D :ABNormal :FREQuency
MIL704D :ABNormal :FREQuency :OVER
MIL704D :ABNormal :FREQuency :UNDer

MIL704D[A][B][C] :EMERgency
MIL704D[A][B][C] :EMERgency :VOLTage
MIL704D :EMERgency :FREQuency
```

All lower case letters are option. [A],[B],[C] represent phase A, B, C. They are optional if they are omitted; the test will be applied to all three phases.

8.6 TEST SPECIFICATION

8.6.1 STEADY STATE

1. Steady state voltage test (Figure 1).

   MIL704D[A][B][C] :STEady state :VOLTage

   This test will change the output voltage simultaneously from 115 volts to 108 volts for 5 seconds to 118 volts for 5 seconds. The unselected phases will remain at 115 volts.

2. Steady state voltage unbalance test (Figure 2).

   MIL704D[A][B][C] :STEady state :VOLTage :UNBalance

   This test will change the output for phase A from 115 volts to 112 volts for 5 seconds and to 118 volts for 5 seconds. The test will repeat itself for phase B and phase C if they are selected.

3. Steady state voltage phase difference test (Figure 3).

   MIL704D[A][B][C] :STEady state :PHASe :DIFFerence

   This test will change phase B program phase angle, if it is selected, from 240 degrees to 236 degrees for 5 seconds and to 244 degrees for another 5 seconds. The test will be repeated for phase C, if it is selected.

4. Steady state waveform distortion (Figure 4).

   MIL704D[A][B][C] :STEady state :WAVeform :DISTortion

   This test will generate a 5% distortion on the selected phase for 5 seconds.

5. Steady state frequency test (Figure 5).

   MIL704D :STEady state :FREQuency

   This test will change the programmed frequency from 400 Hz to 393 Hz for 5 seconds then to 407 Hz for 5 seconds.

6. Steady state test

MIL704D[A][B][C] :STEady state

This test will perform all the above five tests in the same order above. A 5 second pause between tests is asserted.

8.6.2. TRANSIENT

1. Transient high voltage test (Figure 6).

MIL704D[A][B][C] :TRANsient :VOLTage :HIGH

This test requires a 180 volts range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for range change and after 5 seconds the test will begin.

The output will go to 180 volts for 10 msec and will drop gradually to 115 volts in 81.25 msec. After 5 seconds, a range change will take place to the original setup. This is a simultaneous test to all selected phases.

2. Transient low voltage test (Figure 7).

MIL704D[A][B][C] :TRANsient :VOLTage :LOW

The output voltage will drop to 80 volts for 10 msec. It will gradually rise to 115 volts in 81.25 msec. This test is a simultaneous test to all selected phases.

3. Transient voltage test

MIL704D[A][B][C] :TRANsient :VOLTage

This test will combine High voltage transient and Low voltage transient. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts, the High voltage transient test will not take place.

4. Transient high frequency test (Figure 8).

MIL704D :TRANsient :FREQuency:HIGH

This test will step up the frequency from 400 Hz to 425 Hz. The frequency will step down to 400 Hz in the following sequence:

425 Hz for 1 second
420 Hz for 4 seconds
410 Hz for 5 seconds
407 Hz for 4 seconds

5. Transient low frequency test (Figure 9).

MIL704D :TRANsient :FREQuency:LOW

This test will step down the frequency from 400 Hz to 375 Hz. The frequency will step up to 400 Hz in the following sequence:

375 Hz for 1 second
380 Hz for 4 seconds
390 Hz for 5 seconds
393 Hz for 4 seconds

6. Transient frequency test

MIL704D :TRANsient :FREQuency

This test will combine the high frequency transient and the low frequency transient. There is a pause of 5 seconds between tests.

8.6.3. ABNORMAL

1. Abnormal overvoltage test (Figure 10).

MIL704D[A][B][C] :ABNormal :VOLTage :OVER

This test requires a 180 volt range. A range change will take place if the power source is not set for the high range. The output voltage will drop temporarily to allow for the range change and after 5 seconds the test will begin.

The output will go to 180 volts for 50 msec and will drop gradually to 125 volts in 450 msec. The output voltage will remain at 125 volts for 9.5 seconds before it drops to 115 volts. After 5 seconds, a range change will take place to the original setup. This is a simultaneous test to all selected phases.

2. Abnormal undervoltage test (Figure 11).

MIL704D[A][B][C] :ABNormal :VOLTage :UNDer

The output voltage will drop to 0 volts for 7 seconds. It step up to 100 volts for 3 seconds before it will go to 115 volts. This is a simultaneous test for all selected phases.

3. Abnormal voltage test

MIL704D[A][B][C] :ABNormal :VOLTage

This test will combine Abnormal overvoltage and Abnormal undervoltage. There will be a pause of 5 seconds between tests. If the voltage range is below 180 volts the Abnormal overvoltage test will not take place.

4. Abnormal overfrequency test (Figure 12)

MIL704D :ABNormal :FREQuency :OVER

This test will step up the frequency from 400 Hz to 480 Hz. The frequency will step down to 400 Hz in the following sequence:

480 Hz for 5 seconds
425 Hz for 5 seconds

5. Abnormal underfrequency test (Figure 13)

MIL704D :ABNormal :FREQuency :UNDer

This test will step down the frequency from 400 Hz to 0 Hz. The frequency will step up to 400 Hz in the following sequence:

0 Hz for 5 seconds
375 Hz for 5 seconds

6. Abnormal frequency test

MIL704D :ABNormal :FREQuency

This test will combine the Abnormal overfrequency and the Abnormal underfrequency . There is a pause for 5 seconds between tests.

8.6.4. EMERGENCY

1. Emergency voltage test (Figure 14).

MIL704D[A][B][C] :EMERgency :VOLTage

This test will step down the voltage to 104 volts for 5 seconds. Also it will step up the voltage to 122 volts for another 5 seconds.

2. Emergency frequency test (Figure 15).

MIL704D :EMERgency :FREQuency

This test will step down the frequency to 360 Hz for 5 seconds then will step up the frequency to 440 Hz for 5 seconds.

3. Emergency test

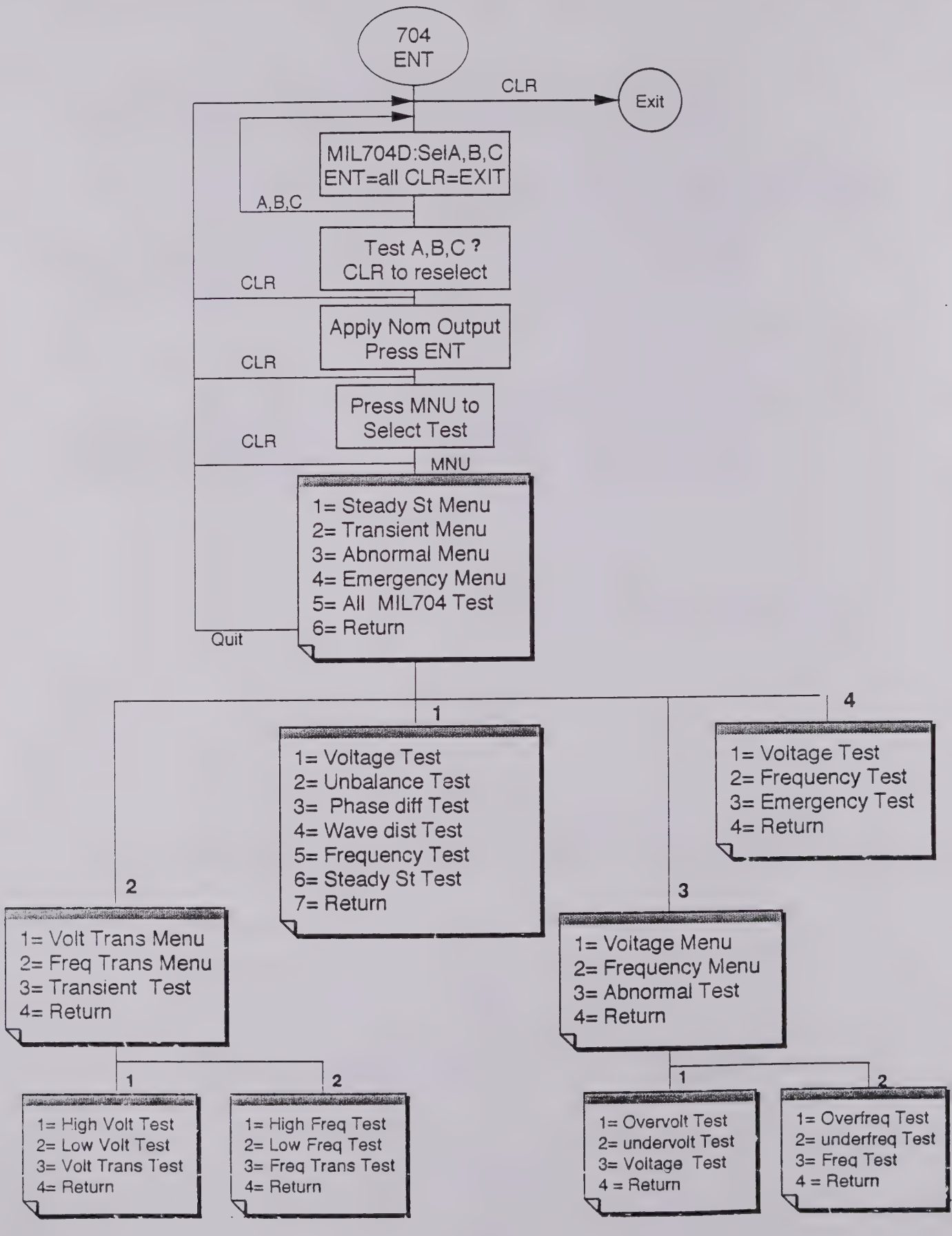
MIL704D[A][B][C] :EMERgency

This test will combine the voltage emergency test and the frequency emergency test. A pause of 5 seconds between tests is asserted.

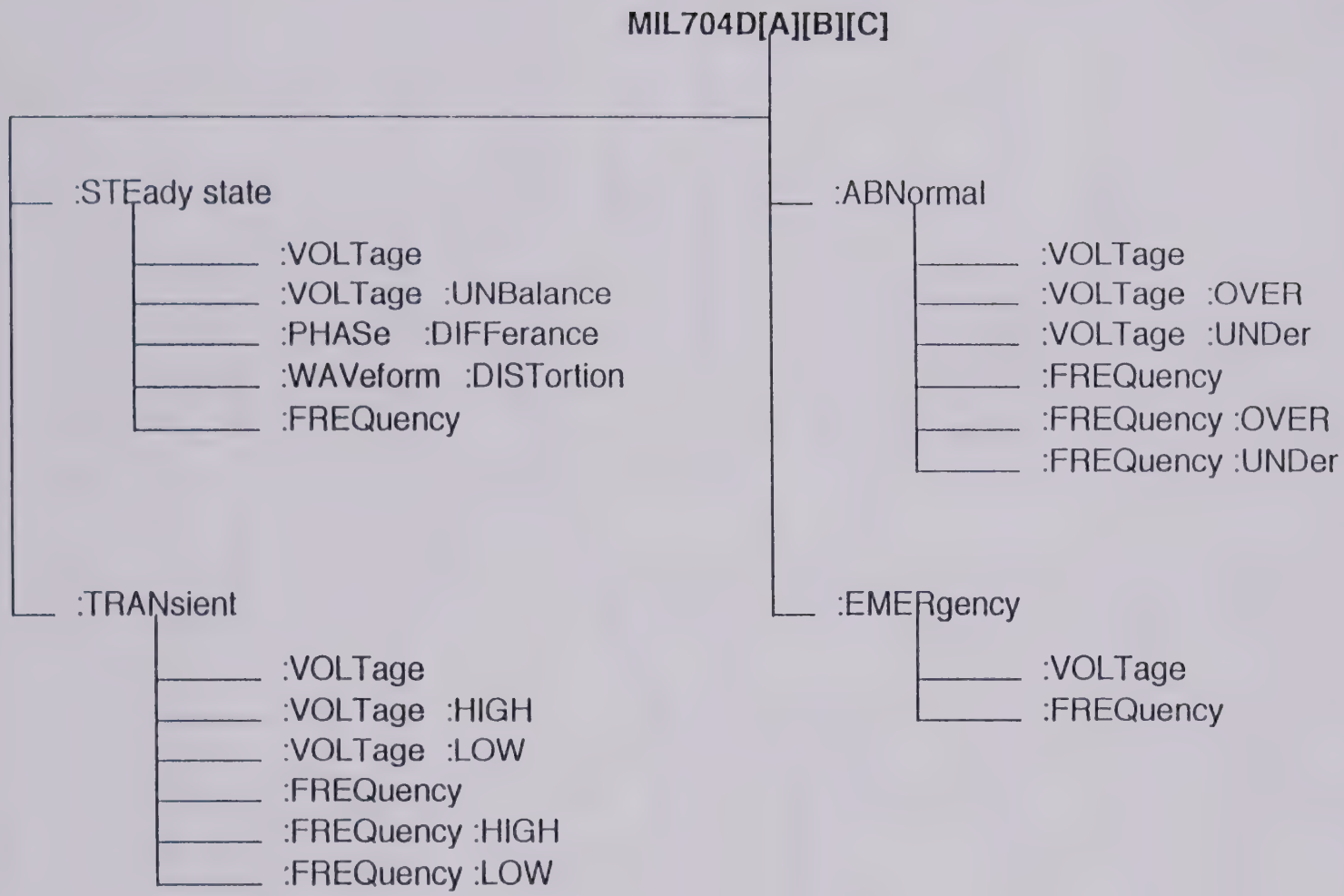
8.6.5 MIL704D TEST

MIL704D[A][B][C]

This test will combine all the tests listed above in one test in the sequence listed. A 5 second time delay separate the parts of the test. Tests will be performed on the selected phases only.



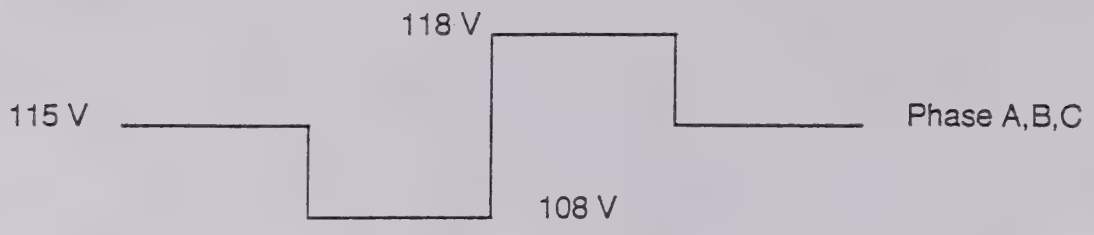
All returns return to previous screen



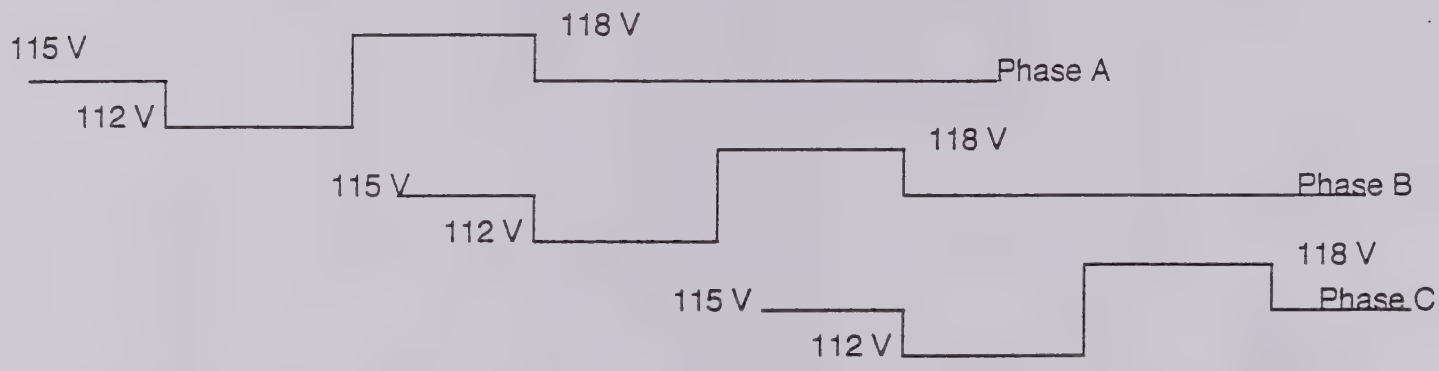
MIL704D SYNTAX FLOW

Steady state

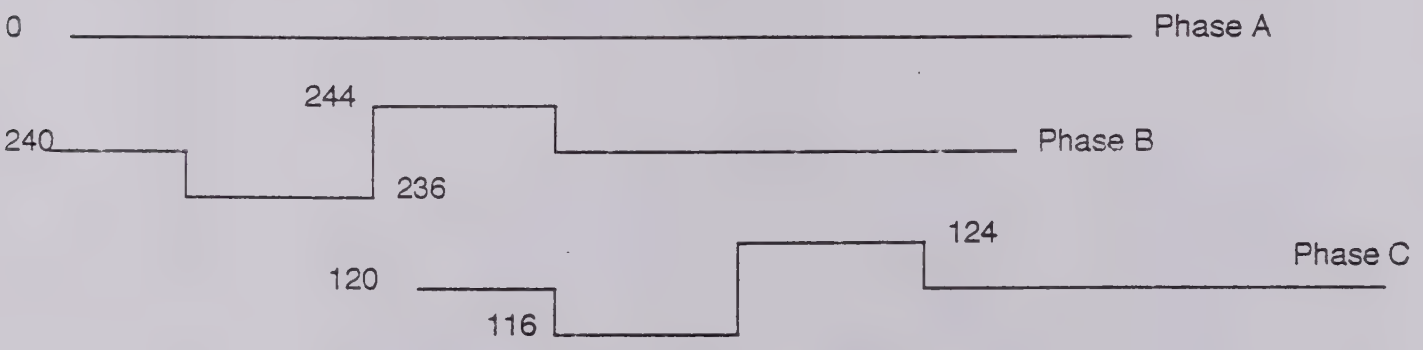
Voltage figure 1



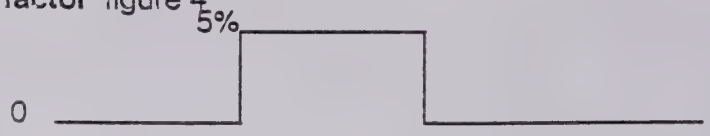
Voltage Unbalance figure 2



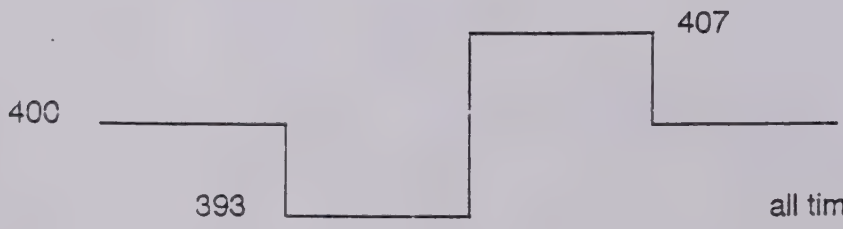
Voltage Phase difference figure 3



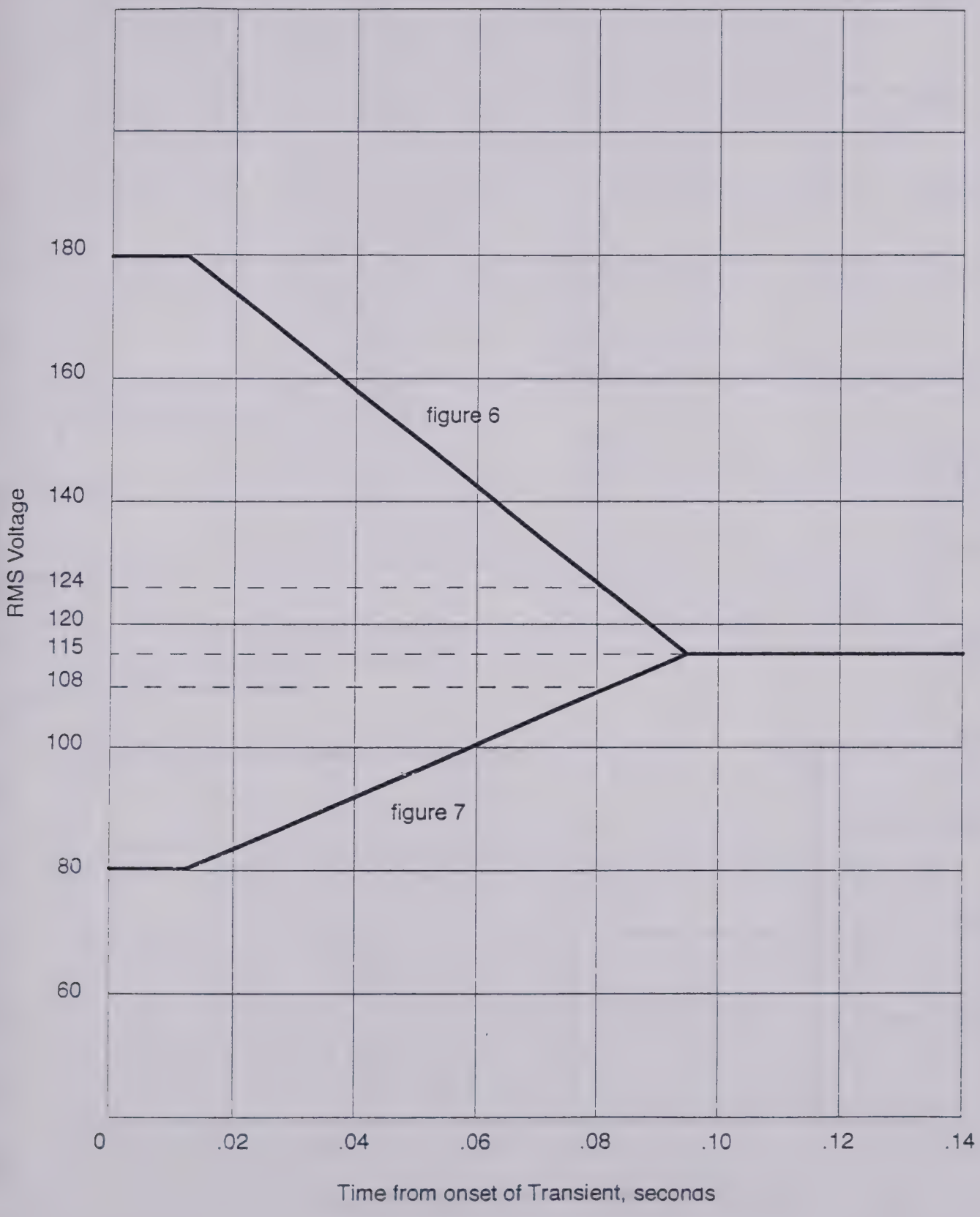
Distortion factor figure 4



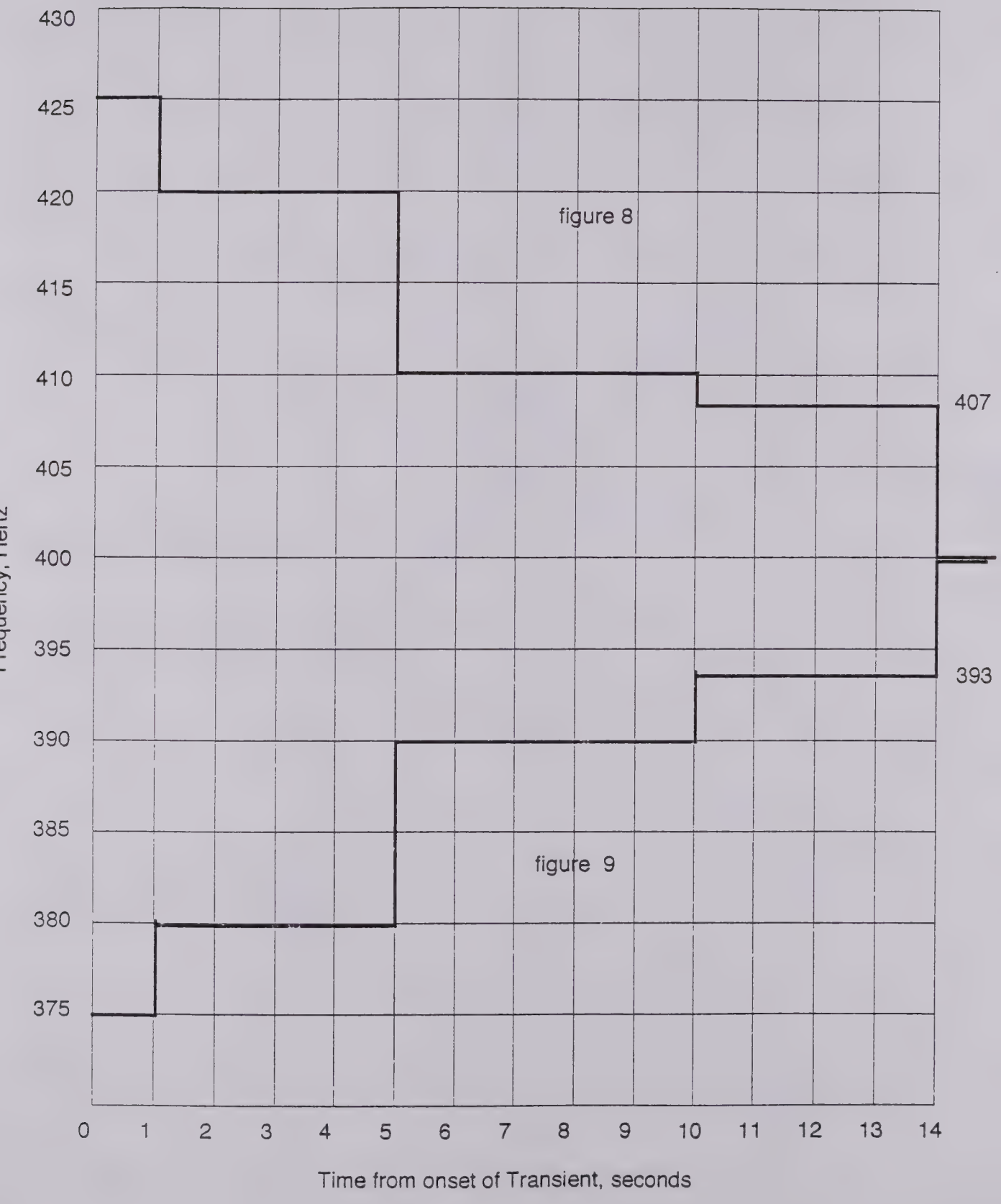
Frequency figure 5



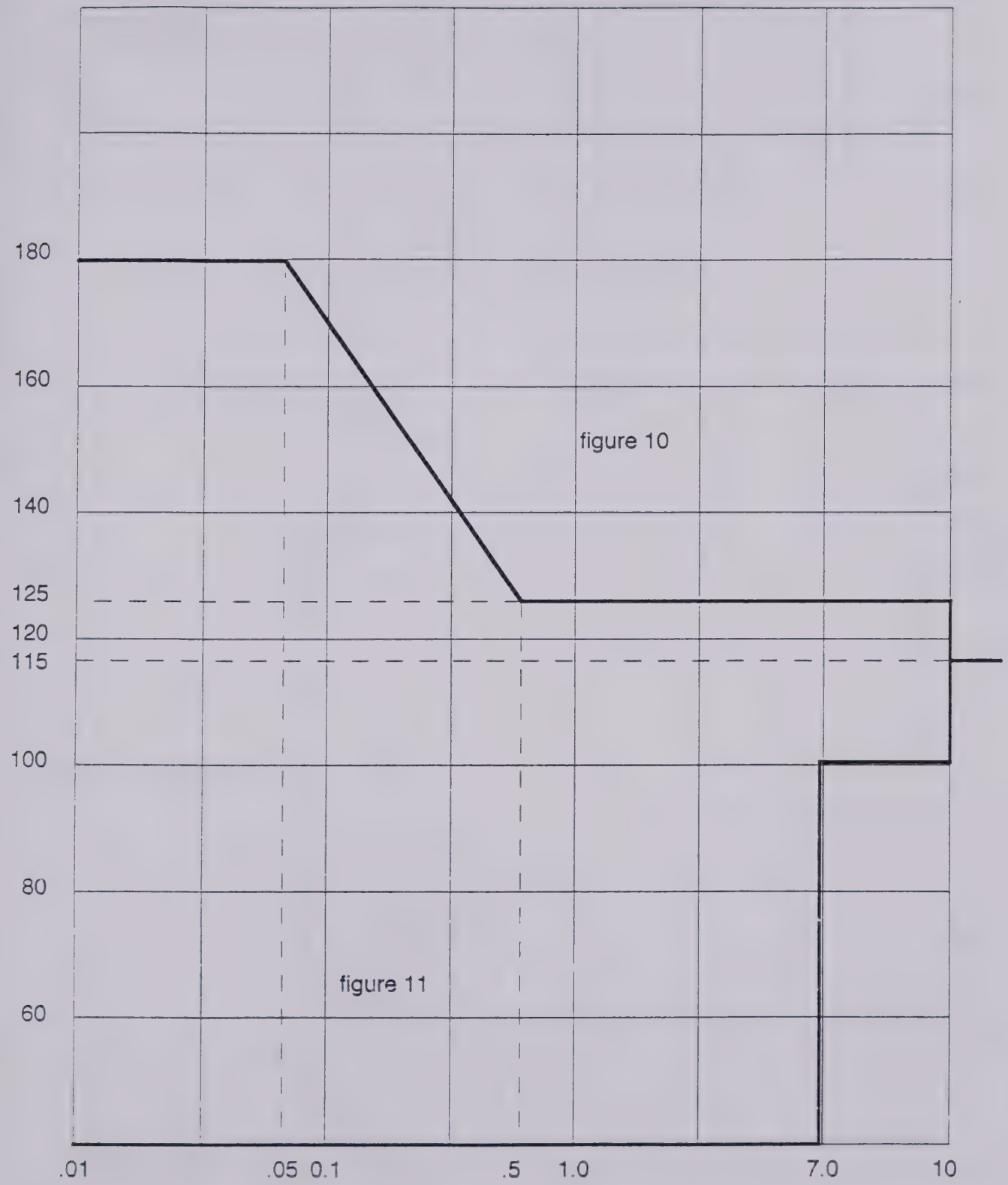
all time interval are 5 seconds



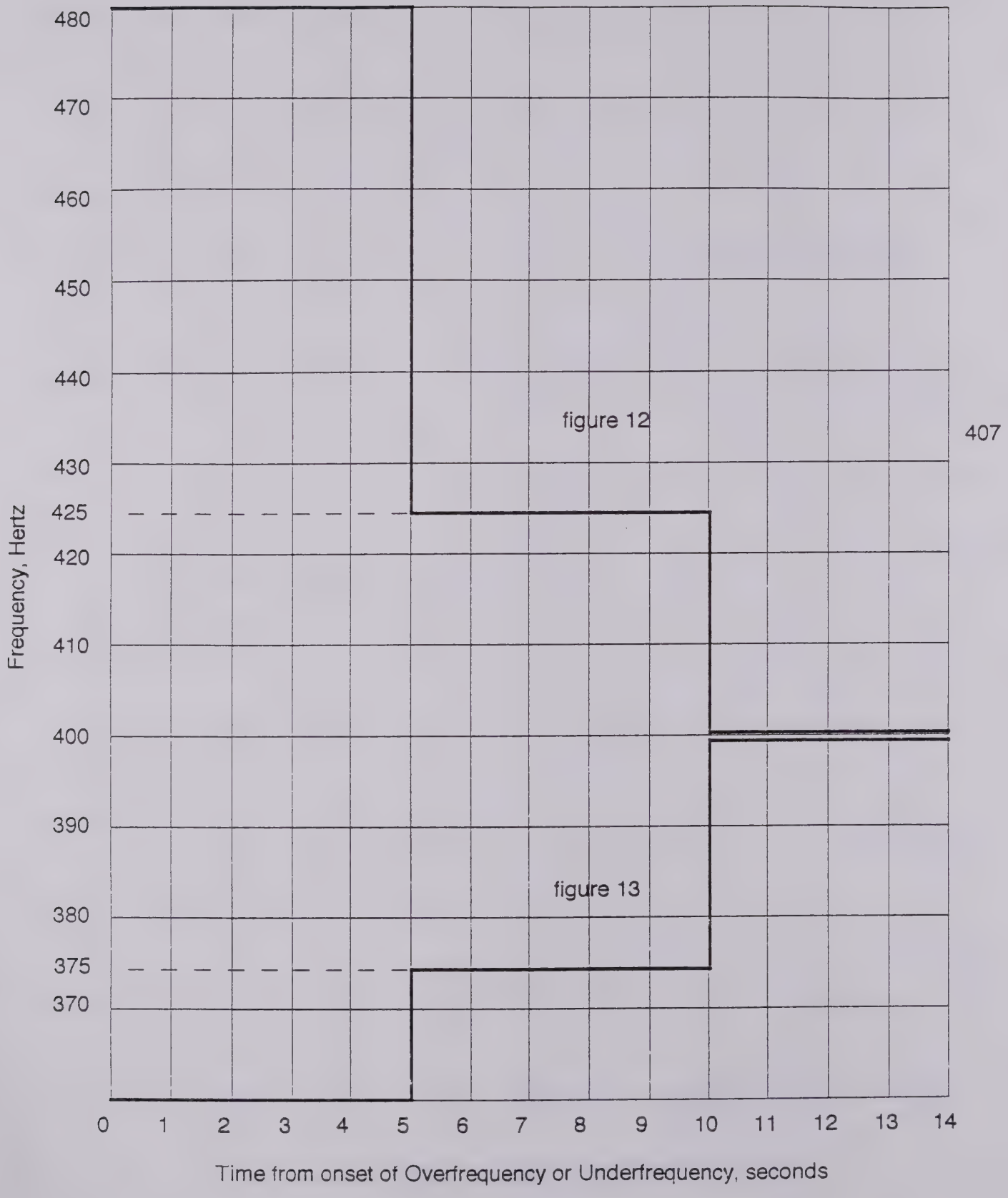
Voltage transient
figure 6,7



Frequency Transient
figure 8,9

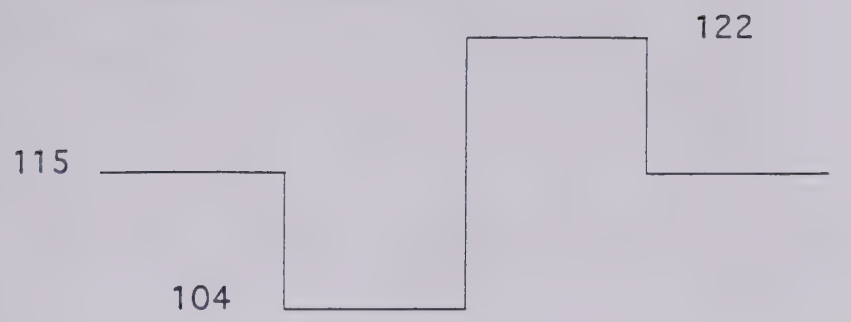


Abnormal operation
figure 10,11

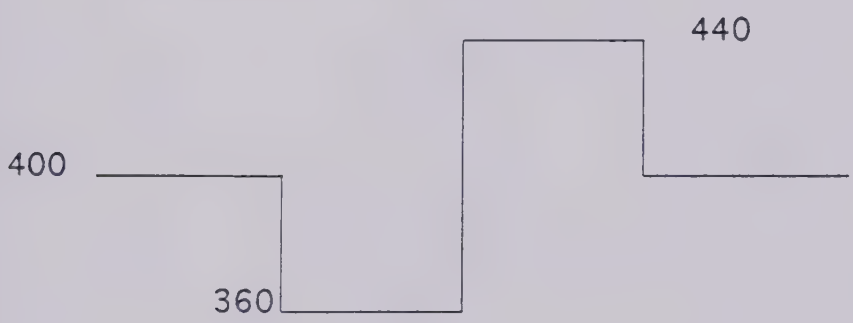


Abnormal Frequency
figure 12,13

Emergency Voltage figure 14



Emergency Frequency figure 15



all time interval are 5 seconds

SECTION 9

2-PHASE OPTION (2P)

9.1 GENERAL

The output appears from the Phase A and Phase C output terminals for this option. Phase C leads Phase A by 90 degrees.

SECTION 10

RTCA/DO-160C

10.1 GENERAL

The RTCA/DO-160C option is capable of performing all sections of RTCA/DO-160C for the AC Source signal.

10.2 INITIAL SETUP

Nominal parameters for the AC Power source shall be as follows:

Output Voltage	115V L-N
Output Frequency	400 Hz
Output Phase Angle	B 240
	C 120

10.3 TEST PERFORMED

10.3.1 NORMAL STATE

1. Normal State Voltage and Frequency test
2. Voltage Unbalance test
3. Waveform Distortion test
4. Voltage Modulation test
5. Frequency Modulation test
6. Momentary Power Interrupt (Undervoltage) test
7. Voltage Surge (Overvoltage) test

10.3.2 EMERGENCY TEST

1. Emergency Voltage and Frequency test
2. Voltage Unbalance test

10.3.3 ABNORMAL TEST

1. Abnormal Voltage and Frequency test
2. Momentary Undervoltage test
3. Voltage Surge test

10.4 KEYPAD ENTRY (Refer to Figure 1 for Keyboard Flow Chart)

To perform a test from the keyboard, the following key sequence is required:

160 ENT

The following screen will appear:

```
DO160C: Sel A, B, C
ENT = all CLR = EXIT
```

Pressing the A, B, C or any combination selects the phase in test. Press ENT without the phase select for simultaneous three phase test.

The following screen appears for a short time:

```
Test A, B, C
CLR to Reselect
```

The next screen is:

```
Apply Nom output
Press ENT
```

When ENT is selected the following screen appears;

```
Press MNU to
Select Test
```

The MNU screen has two lines of selection shown at a time.

There are three different types of operations that can be selected from the MENU screen. If the word MENU appears for the items selected, another MENU screen will be displayed. If the word Test appears for the item selected, the test will start. The display will return to the previous screen if the word RETURN appears for the item selected.

The Main Menu will appears as follows:

```
1 = Normal Menu
2 = Emergency Menu
3 = Abnormal Menu
4 = Return
```

If Key 1 is selected "Normal Menu" from the Main Menu, the following Menu will appear:

```
1 = Volt/Freq Menu
2 = Unbalance Test
3 = Volt Mod Test
4 = Power Int Test
5 = Volt Surge Test
6 = Wave Dist Test
7 = Freq Mod Test
8 = Return
```

If Key 2 is selected "Emergency Menu" from the Main Menu, the following Menu will appear:

```
1 = Emg V/F Menu
2 = Emg Unbal Test
3 = Return
```

If Key 3 is selected "Abnormal Menu" from the Main Menu, the following Menu will appear:

```
1 = Ab Volt Menu
2 = Ab Vunder Test
3 = Ab Vsurge Test
4 = Return
```

If Key 1 is selected "Volt/Freq Menu" from the Normal Menu, the following Menu will appear:

```
1 = Under Volt Test
2 = Over Volt Test
3 = Return
```

If Key 1 is selected "Volt/Freq Menu" from the Emergency Menu, the following Menu will appear:

```
1 = Emg Vunder Test
2 = Emg Vover Test
3 = Return
```

If Key 1 is selected "Volt Menu" from the Abnormal Menu, the following Menu will appear:

```
1 = Ab Vunder Test
2 = Ab Vover Test
3 = Return
```

If Key 3 or Key 7 is selected from the "Normal Menu", another screen will appear as follows:

Enter Modulation
Rate in Hz and ENT.

The numeric value must be within the limits for the test performed. See Figure 2 and Figure 3.

If Key 4 is selected from the "Normal Menu", the following screen will appear as follows:

Enter Test
Number 1 to 15 and ENT (see Table 1)

10.5 GPIB OPERATION

The following command will be used to execute the appropriate section of DO-160C.

Remote Command

Items contained within square brackets [ ] are optional.

DO160[A][B][C] :NORMal state :VOLT_FREQ :MINinum
DO160[A][B][C] :NORMal state :VOLT_FREQ :MAXimum
DO160[A][B][C] :NORMal state :VOLTage :UNBalance
DO160[A][B][C] :NORMal state :WAVe form :DISTortion
DO160[A][B][C] :NORMal state :VOLTage :MODulation <numeric>
DO160[A][B][C] :NORMal state :FREQency :MODulation <numeric>
DO160[A][B][C] :NORMal state :VOLTage :UNDer<numeric>
DO160[A][B][C] :NORMAL state :VOLTage :OVER

DO160[A][B][C] :EMERgency :VOLT_FREQ :MINimum
DO160[A][B][C] :EMERgency :VOLT_FREQ :MAXimum
DO160[A][B][C] :EMERgency :VOLTage :UNBalance

DO160[A][B][C] :ABNormal stage :VOLTage :MINimum
DO160[A][B][C] :ABNormal state :VOLTage :MAXimum
DO160[A][B][C] :ABNormal stage :VOLTage :UNDer
DO160[A][B][C] :ABNormal state :VOLTage :OVER

10.6 TEST SPECIFICATION

10.6.1 NORMAL STATE

10.6.1.1 Normal State Minimum Voltage and Frequency Test

DO160[A][B][C] :NORMal state :VOLT_FREQ :MINimum

This test will change the output voltage for single phase from 115V to 104V and for three-phase from 115V to 105.5V and the frequency from 400 Hz to 380 Hz. The test will last for 30 minutes. The CLR Key in local operation will terminate the test at any time. Group execute trigger will terminate the test remotely. The unselected phases will remain at 115 volts.

10.6.1.2 Normal State Maximum Voltage and Frequency Test

DO160[A][B][C] :NORMal state :VOLT_FREQ :MAXimum

This test will change the output voltage for single phase from 115V to 122 volts and from 115V to 120.5 volts for three-phase and the frequency from 400 Hz to 420 Hz. The test will last for 30 minutes. The CLR Key in local operation will terminate the test at any time. Group execute trigger will terminate the test remotely. The unselected phase will remain at 115 volts.

10.6.1.3 Normal State Voltage Unbalance

DO160[A][B][C] :NORMal state :VOLTage :UNBalance

This test will change the output voltage for each phase from 115 volts to 112 volts and to 118 volts. The test for all three phases will last 30 minutes. The test can be terminated at any time.

10.6.1.4 Normal State Waveform Distortion

D0160[A][B][C] :NORMal state :WAVe form :DISTortion

This test will generate a 5% distortion on the selected phase. The test will last for 30 minutes. This test can be terminated at any time.

10.6.1.5 Normal State Voltage Modulation

DO160[A][B][C] :NORMal state :VOLTage :MODulation <numeric>

This test requires a numeric value equal to the modulation rate in Hz. See Figure 2. The amplitude modulation is calculated based on the modulation rate. This test will last for 2 minutes.

10.6.1.6 Normal State Frequency Modulation

DO160[A][B][C] :NORMal state :FREQency :MODulation <numeric>

This test requires a numeric value equal to the modulation rate in Hz. See Figure 3. The frequency modulation is calculated based on the modulation rate. This test will last for two minutes.

10.6.1.7 Normal State Power Interrupt

DO160[A][B][C] :NORMal state :VOLTage :UNDer<numeric>

This test requires a numeric value equal to the test number. There are 15 tests. See Table 1.

10.6.1.8 Normal State Voltage Surge

DO160[A][B][C] :NORMAL state :VOLTage :OVER

This test requires a power source with 160 volt output. If the power source has a dual voltage range, the test will select the high voltage range to complete the test.

The output voltage will remain at 115 volts for 5 minutes before it rises to 160 volts for 30 msec then stays for 5 seconds at 115 volts then drops to 60 volts for 30 msec before returning to 115 volts for 5 seconds. The above sequence will repeat itself three times.

10.6.2 EMERGENCY TEST

This test could be performed in addition to the Normal State test for equipment designed to operate under emergency electrical system.

10.6.2.1 Emergency State Minimum Voltage and Frequency Test

DO160[A][B][C] :EMERgency :VOLT_FREQ :MINimum

This test is similar to the test at 6.1.1 except the output frequency changes from 400 Hz to 360 Hz.

10.6.2.2 Emergency State Maximum Voltage and Frequency Test

DO160[A][B][C] :EMERgency :VOLT_FREQ :MAXimum

This test is similar to the test at 10.6.1.2 except the output frequency changes from 400 Hz to 440 Hz.

10.6.2.3 Emergency State Voltage Unbalance

DO160[A][B][C] :EMERgency :VOLTage :UNBalance

This test is similar to the test at 10.6.1.3 except the output voltage changes from 115 volts to 111 volts and from 115 volts to 119 volts.

10.6.3 ABNORMAL STATE

10.6.3.1 Abnormal State Minimum Voltage

DO160[A][B][C] :ABNormal stage :VOLTage :MINimum

This test will drop the output to 97 volts for 5 minutes

10.6.3.2 Abnormal State Maximum Voltage

DO160[A][B][C] :ABNormal state :VOLTage :MAXimum

This test will raise the output voltage from 115 volts to 135 volts for 5 minutes.

10.6.3.3 Abnormal State Undervoltage

DO160[A][B][C] :ABNormal stage :VOLTage :UNDer

This test will drop the output voltage from 115 volts to 60 volts for 7 seconds.

10.6.3.4 Abnormal State Voltage Surge

DO160[A][B][C] :ABNormal state :VOLTage :OVER

This test requires an output voltage range of 180 volts. If the power source is a dual voltage range, this test will select the upper voltage range if the lower voltage ranges is less than 180 volts.

The output voltage will rise to 180 volts for 100 msec and will drop to 148 volts for 1 sec before it returns to 115 volts.

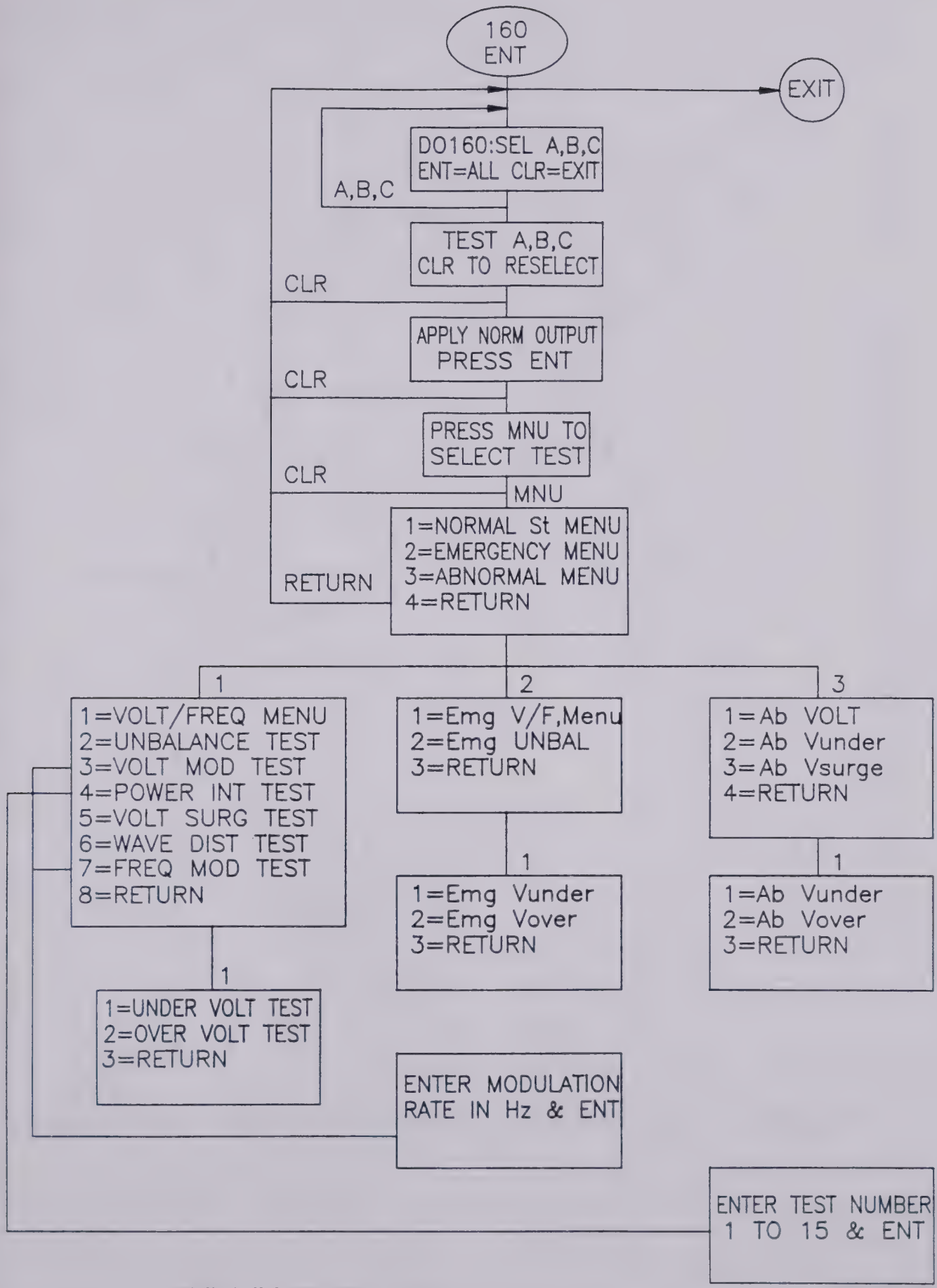
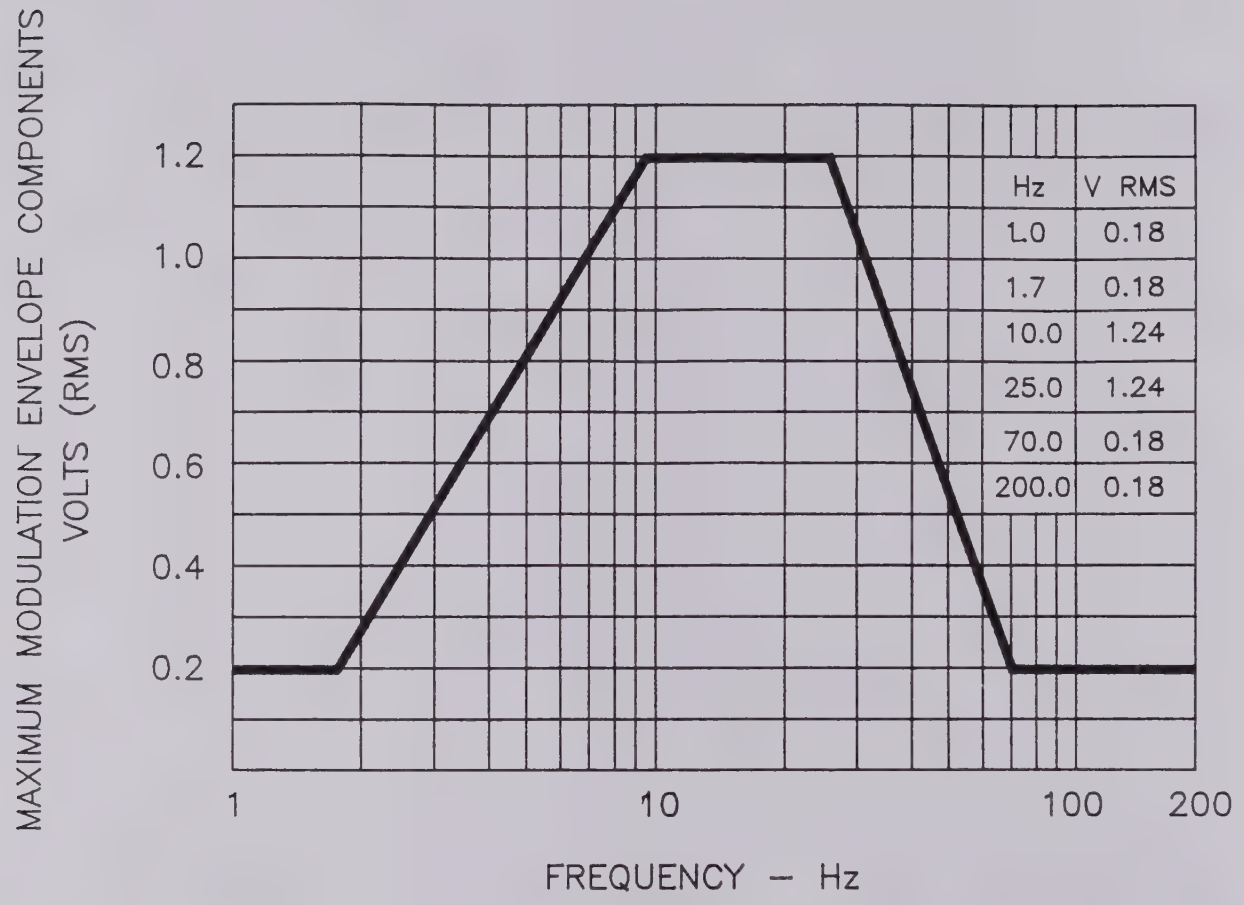


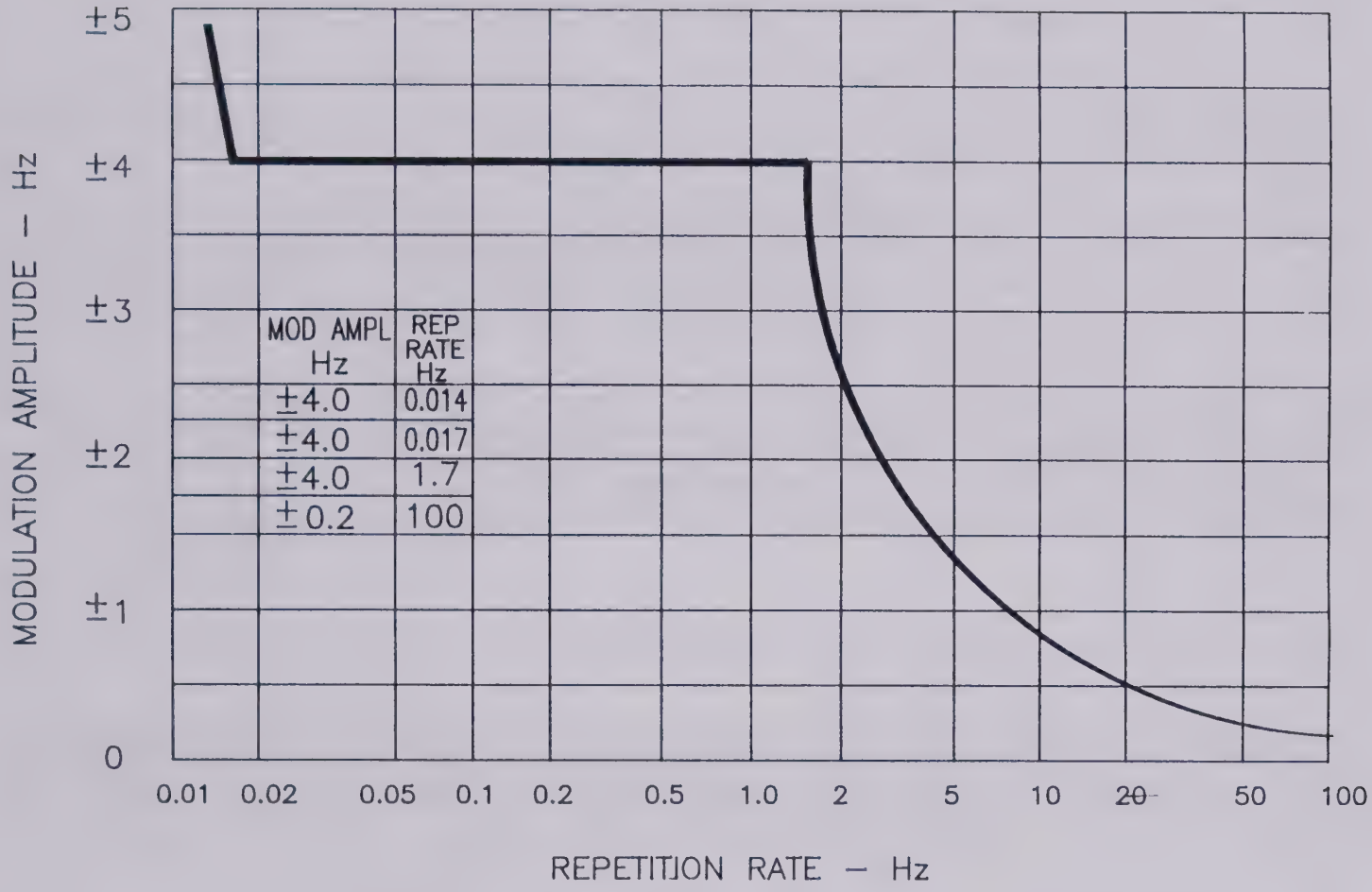
FIGURE 1

All returns return to previous screen



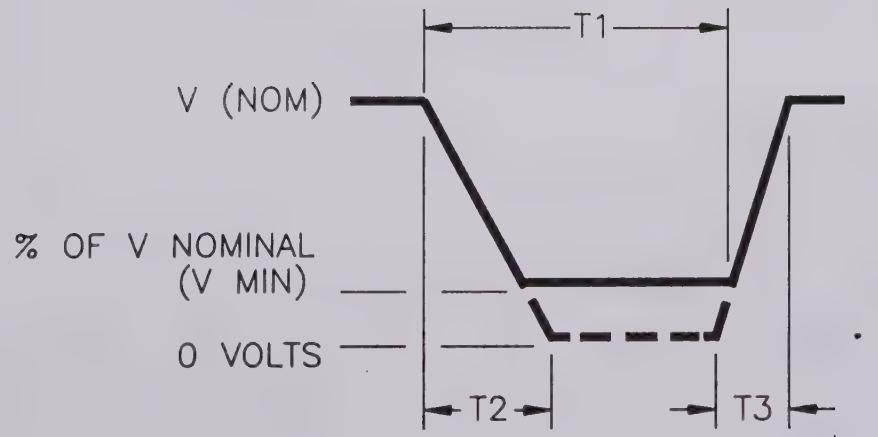
FREQUENCY CHARACTERISTICS OF AC VOLTAGE MODULATION ENVELOPE

FIGURE 2



CHARACTERISITICS OF AC FREQUENCY MODULATION

FIGURE 3



NOTES: 1. Definitions

T1 – Power interrupt time.
T2 – Time it would take for the applied voltage to decay from V (nom) to zero volts>
T3 – Time it would take for the applied voltage to rise from zero to V (nom) volts.
V MIN – The minimum level (expressed as a percentage of V NOMINAL) to which the applied voltage is permitted to decay.

2. Tolerance to T1, T2 and V MIN = ±10%

TEST CONDITION NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1 (MILLISECONDS)	2	10	25	50	75	100	200	1000	10	25	50	75	100	200	1000
T2 (MILLISECONDS)	<1	20*	20	20	20	20	20	20	50*	50*	50	50	50	50	50
T3 (MILLISECONDS)	<1	5	5	5	5	5	5	5	20	20	20	20	20	20	20
% OF V NOMINAL (V MIN)	0	50	15	10	5	0	0	0	20	50	0	15	5	0	0

* VOLTAGE WILL NOT REACH ZERO IN THIS TEST CONDITION.

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waddon,Surrey	GB
0000S(28564)	OPCDA (Refac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
0000Z(52745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	Lafrance	Philadelphia	PA
000AH(54363)	Jan Crystal	Ft. Myers	CA
000AL(53495)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AN	Ritz Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(62643)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(61837)	Semi Processes, Inc.	San Jose	CA
000AW	Hirose	Chatsworth	CA
000AX(63878)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(61271)	Fujitsu	Santa Clara	CA
000BA(61964)	Omron Electronics, Inc.	Schaumburg	IL
000B8	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BD(55982)	Electronic Essentials	Woodside	NY
000BF(57856)	Kel-Am	Eldon	MO
000BF(55285)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54186)	Micro Power Systems	Santa Clara	CA
000BJ(06776)	Robinson Nugent	New Albany	IN
000BL(13150)	Beau Products (Vernitron)	Laconia	NH
000BM(91725)	Corebinder (Gerrard AJ & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secme	Bagnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stanford, Wyco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burrington	IA
07910	Use Code #15818		
08028	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Amphenol)	Garden Grove	
08289	Blinn Delbert Co.	Pomona	CA
09353	Bristol Co. of Canada	Toronoto, Ont	Canada
08710	Oxsby & Barton (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12406	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13604	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Amerac Enk (Rodan Div)	Anaheim	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Ameico Teledyne, Inc.	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Gmpco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scanbe Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Manovec	NJ
19080	Robison Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23936	Pamotor, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24155	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Inc.	Tempe	AZ
24796	Pareico, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Ittelec, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Inc.	St. Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28606	Echlin Ltd.	Rexdale Ont.	Canada
29372	Rexnord Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng., Inc.	El Segundo	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Dorann Company	Sylmar	CA
30983	Electra/Midland (Mepco/ Electra)	San Diego	CA
31827	Budwig Mfg. Co.	Ramona	CA
31951	Tricidge, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Colbec Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Mouser Corp.	Santee	CA
51167	Arlen Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Hutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Kintex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camarillo	CA
55322	Samtek, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kel-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milditas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Densitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Stac Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Lavitan Mfg. Co.	Little Neck	NY
75915	Littlefuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77062	Pabst Eng. Equipment Co.	Elizabeth	NJ
77133	United-Carr Inc., Pacwin Div	Waterbury	CT
77342	Potter and Brumfield Div, AMF	E. Princeton	IN
78189	Shakeproof Div, IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79136	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Sierick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81603	Raco Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
83540	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Oseco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91967	National Electronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94696	Magnecraft Electric Co.	Chicago	IL
95144	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95987	Wechsler Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Teck, Inc.	Gardena	CA
98291	Sealecto Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99017	Protective Closures Co., Inc. (Capluge Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delaven	WI
99742	Permacell	New Brunswick	NJ
99743	INC	Haywood	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are fuses and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA number to shipping label. .Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No. or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested when it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

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